DOCUMENT RESUME

ED 082 028 CE 000 326

TITLE	Equipment Operator 3 and 2. NAVTRA 10640-G. Rate Training Manual.
INSTITUTION	Bureau of Naval Personnel, Washington, D.C.; Naval Personnel Program Support Activity, Washington, D. C.
REPORT NO	NAVTRA-10640-G
PUB DATE	73
NOTE	473p.; Revised Edition
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 0502-053-2010)
EDRS PRICE	MF-$0.65 HC-$16.45
DESCRIPTORS	*Construction (Process); *Equipment; *Job Training; *Manuals; *Military Personnel; Skilled Occupations; Vocational Education
IDENTIFIERS	*Equipment Operator

ABSTRACT

A guide for advancement and training in the Equipment Operator 3 and 2 ratings for Navy personnel is provided in this manual. The chapters outline the duties and responsibilities of the equipment operators involved with engines, fuels, lubricants, pollution control, automotive power trains and chassis, automotive vehicles, materials-handling equipment, construction and maintenance equipment, earthwork, tractors and attachments, front-end loaders, power cranes and attachments, motor graders, scrapers, rollers, ditchers, earth augers, air compressors, rock drills, paving equipment and operations, handling and hauling explosives, and administration. There are extensive diagrams, drawings, and photographs together with an appendix containing equipment operator hand signals. (KP)

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EQUIPMENT OPERATOR 3 & 2

NAVAL TRAINING COMMAND

RATE TRAINING MANUAL NAVTRA 10640-G

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PREFACE

The primary purpose of training is to produce a combat Navy which can ensure victory at sea. A victorious Navy is dependent upon the superior readiness of personnel. A superior quality of training will ensure superior readiness.

This Rate Training Manual provides the technical knowledge and skill requirements necessary to prepare personnel to perform tasks involved in the deployment and operation of automotive, materials-handling, weight lifting, and construction equipment; and to assist in directing and coordinating efforts of personnel in the execution of construction, earthmoving, roadbuilding, asphalt paving, and transit mixer operations.

This training manual was prepared by the Navy Training Publications Detachment, Washington, D.C., for the Chief of Naval Training. Technical assistance was provided by the Naval Facilities Engineering Command; the Naval Examining Center; the Naval Schools Construction, Port Hueneme, California; the Naval Schools Construction, Davisville, Rhode Island; and the Naval Construction Training Unit, Gulfport, Mississippi.

Revised 1973

Stock Ordering No.
0502-053-2010

Published by
Naval Training Command

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON, D.C.: 1973

CE 000 326

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CHAPTER 1

MEET THE EQUIPMENT OPERATOR

INTRODUCTION

This training manual is designed to help you meet the qualifications for advancement to Equipment Operator Third Class or Equipment Operator Second Class. To be eligible for advancement, you must fulfill certain requirements which are explained in this chapter.

One of the major requirements for advancement is that you possess or acquire certain qualifications (often called "quals") that have been specifically prescribed for each pay grade or rate level of your particular rating. These quals are often referred to as "standards" for advancement or as "qualification requirements" for advancement. Since the quals for each rating deal with the technical or occupational subject matter of that rating, they are often called "occupational quals," "professional quals," or "technical quals."

In addition to the occupational, professional, or technical quals prescribed for each rating, there are certain military qualifications or requirements to be met. The military requirements for advancement are discussed briefly later in this chapter and are discussed in detail in special training manuals prepared to cover the military requirements for advancement.

The occupational, professional, or technical quals for the Equipment Operator rating that were used as a guide in the preparation of this training manual are contained in the Manual of Qualifications for Advancement, NAVPERS 18068-C.

This chapter deals with the scope of the Equipment Operator rating and the types of billets to which you may be assigned. Requirements and procedures for advancement are discussed, as well as references that will help you both in working for advancement and in performing your duties as an Equipment Operator. This chapter also includes information on how to make the best use of Rate Training Manuals. Therefore, it is strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of this training manual.

Chapter 2 of this manual presents information related to the administrative duties and safety responsibilities of supervisory crew leaders. Engines, fuels, lubricants, and pollution control are considered in chapter 3. Automotive power trains and chassis are described in chapter 4. Chapter 5 includes information on automotive vehicle operation. Materials-handling equipment is described in chapter 6. Construction and maintenance equipment, fundamentals of gradework, operation and maintenance of earthmoving, excavating, grading, hauling, drilling, paving equipment; and handling and hauling of explosives are covered in chapters 7 through 17.

In studying this training manual, you will find a definite relationship between the scope of the manual and the Equipment Operator qualifications for advancement. This training manual contains information you will need to know in order to advance to EO3 and EO2. It does not contain information that is primarily required for advancement to first class or chief; such information is given in the training manual, Equipment Operator, 1 & C.

THE ENLISTED RATING STRUCTURE

The two main types of ratings in the present enlisted rating structure are general ratings and service ratings.

GENERAL RATINGS identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

An example of the General Rating is the Equipment Operator (EO) Rating which is a straight progression from Construction Recruit (CR) to Master Chief Equipmentman (EQCM).

Equipment Operator
CR-CA-CN-EO3-EO2-EO1-EOC-EOCS-EQCM

SERVICE RATINGS identify subdivisions or specialties within a general rating. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

The Electronics Technician (ET) is an example of a general rating which has two service ratings within its structure from Seaman Apprentice (SA) to Electronics Technician First Class (ET1). This provides for specialization in training and utilization of personnel.

This general rating career pattern is as follows:

Electronics Technician

SR- SA-SN-ETN3-ETN2 / SA-SN-ETR3-ETR2 -ET1-ETC-ETCS-ETCM

THE EQUIPMENT OPERATOR RATING

The Equipment Operator rating is a general rating at all levels. As an EO3 or EO2, the scope of your responsibilities is to become familiar with the entire EO rating. The duties and requirements of an EO vary from one project to the next, and from station to station.

Equipment Operators operate and service automotive, material-handling, and paving equipment, and stationary processing plants; transport personnel and materials; perform operator's service checks on such vehicles as buses, trucks, semitrailers, and forklifts; operate asphalt batching plants and rock-crushing plants; and maintain required records for, and dispatch, automotive equipment.

Equipment Operators also operate and service construction and earthmoving equipment; read and follow gradestakes in excavating, filling, and grading areas to specifications; operate shovels and cranes in loading, lifting, excavating and piledriving; adapt cable assemblies and change attachments on equipment; maintain required records on assigned equipment, prepare material requisitions; and always observe and practice safety precautions and procedures.

TYPES OF BILLETS

The great majority of Equipment Operator billets are located in mobile construction battalions, construction battalion units, construction battalion maintenance units, and regiments, most of which are engaged in overseas base construction. In addition, Equipment Operators are frequently assigned to a variety of billets in the Public Works Departments of naval shore activities. A limited number of expecially well-qualified Equipment Operators, usually PO2, PO1, and CPO, are assigned as instructors or to the maintenance section at the Equipment Operator Schools, Port Hueneme (California), Davisville (Rhode Island) and Gulfport (Mississippi).

Geographic Location

The Navy, as you know, maintains a large number of activities within the United States, mostly along the coastlines. As an EO, you may work at almost any one of them, either as a member of a unit of the Fleet operating at the station, or as a member of the station force itself.

In the Atlantic area you may be assigned to duty in Turkey, Spain, Italy, England, Scotland, Newfoundland, or even Iceland or Greenland. You may work in Bermuda or at a number of other islands: Cuba, Puerto Rico, Trinidad, Barbados, Antigua, Turks Island, San Salvador and so on. You may have the opportunity to winter over in Antarctica.

In the Pacific area you may be assigned duties in Japan, Alaska, Formosa, Korea, Guam, Saipan, or the Philippines. You may even work in Thailand, Cambodia, Viet Nam, or Indonesia.

Units of the Fleet

Chapter 1 of Constructionman, NAVPERS 10630-E, includes information on the control and command of the Seabee units of the operating forces. You may wish to review that chapter at this time. As an EO, you may not expect to be assigned to duty as a member of a ship's company. There is a possibility that you may be assigned to an amphibious construction battalion, but you will most likely be assigned to an NMCB, or a detachment thereof, or to other activities related to the Fleet Construction Force such as a CBMU, CBU, regimental headquarters, or Construction Force headquarters. In an NMCB, you may expect to be in "A" company, which is militarily a machine gun and 3.5 rocket company, and construction wise is known as the "equipment company." Equipment Operators and Construction Mechanics are usually assigned to "A" company.

The Public Works Department

When you are assigned to duty at a shore activity, either within the United States or overseas, you will most likely be assigned to the Public Works Department of the station. Most stations which have more than about 100 men and 15 or 20 buildings have a Public Works Department (which administers and maintains public works and utilities), except that in some localities Public Works Centers have been established. These Centers perform the public works duties for a number of Navy activities in the vicinity of the Center. The Public Works Department is headed by the Public Works Officer, who is an officer of the Civil Engineer Corps. The organization and staffing of the Department varies considerably, depending on the size, location, and mission of the activity.

The larger Public Works Departments are generally divided into Administrative and Technical Divisions (Administrative, Engineering, Maintenance Control, and sometimes Housing) and Operating Divisions (Maintenance, Utilities, and Transportation). The Operating Divisions are usually headed by a CEC officer who has the title Shops Engineer. Smaller stations might have only three divisions: Administrative, Engineering, and Shops. The Shops Division usually has a Transportation Branch.

Some Public Works Departments, particularly at small, isolated stations, may be staffed entirely by military personnel, but most Public Works Departments, both in the United States and overseas, are staffed largely by civilians. The Administrative and Technical Divisions (except for Maintenance Control) are mainly staffed with civil servants classed as "GS," or "per annum," or "white collar" employees. The Operating Divisions are mainly staffed with civil servants classed as "wage board," or "per diem," or "blue collar" employees. Supervisory blue collar employees have titles such as (in ascending order of responsibility) snapper, head, leadingman, quarterman, and chief quarterman. Very large stations may also have master mechanics and foreman mechanics. At bases overseas, foreign nationals may be hired to work in the Public Works Department. They may be employed directly as a special category of civil servant, or they may be utilized as contract labor through the negotiation of a labor contract with the host government of the country involved.

Duty Within the U.S.

As stated before, if you are assigned to shore activity within the U.S. you will most likely be assigned to Public Works; but this is not always the case. In areas where there is a large stable supply of manpower, most of the transportation work is done by blue collar employees. Therefore, you may be assigned to the master-at-arms force, special services, the salvage yard, the commissary, or to any of a great variety of jobs.

Your chances of working at your trade are much better in areas where there is a relative shortage of manpower. In these areas, you may expect to be assigned to the Transportation Division or the Transportation Branch of the Shops Division. Some Public Works officers prefer to organize two separate lines of authority: one for civilians and one for the military personnel. Others prefer to integrate the civilians and military completely; in the latter case you may work beside a civilian and report to an EO1 who reports to a quarterman who, in turn, answers to the Shops Engineer who is an officer. There are some activities which are staffed completely by military personnel because the mission is highly classified; if you are assigned to a station of this type you may expect to work within your rating.

Duty at Overseas Bases

In general, you may expect to work in your trade if assigned to a shore activity outside the U.S. At smaller, relatively isolated stations the entire Public Works staff may be military personnel. At the larger activities you may expect to work with civil servants from the U.S., both white collar and blue collar, and with foreign nationals.

PRACTICAL LEADERSHIP ASPECTS

General Order 21, promulgated 17 May 1958, stressed the need to develop and improve our naval leadership in all its aspects: inspirational, technical, and moral. The revised General Order 21 of 1 May 1963 directs our efforts toward achieving an ever-improving state of combat readiness through effective naval leadership. It emphasizes that effective leadership is based on personal example, good management practices, and moral responsibility. It also stresses that every man and woman in the Navy will themselves be examples of military ideals and that personal attention and supervision will be given subordinates. Every command is required to ensure that those in responsible positions discharge their duties in accordance with U.S. Navy Regulations.

In many ships and stations, leadership programs have produced gratifying results, but if we are to raise leadership standards throughout the Navy, the wholehearted efforts of all hands are needed. This requisite means that every person should examine his conduct, review his duties and responsibilities, and determine how well he is performing. To live up to the spirit of General Order 21, you then must plan how to raise your level of performance and that of the men in your charge. The art of leading people can be difficult, but it has many rewards.

Your status as a Constructionman might be roughly described as that of a relatively unskilled construction worker with little or no responsibility for the training and supervision of subordinates. Your status as an Equipment Operator Third will be that of a more highly skilled construction worker with a larger responsibility for the training and supervision of subordinates.

In short, when you become a petty officer you become a link in the chain of command which extends from the battalion CO down through the various officer grades and petty officer rates to the nonrated men in the battalion. Your responsibilities are more than just giving orders and seeing that work is done. You also have a responsibility for sharing your knowledge with others. When you become a petty officer, the Navy expects you to do your part in the training of the men under you.

The general principles of military leadership and supervision, many of which are also applicable in the Equipment Operator's technical field, are described at length in NAVPERS 10056 Military Requirements for Petty Officers 3 & 2, especially in Chapter 6, Leadership.

After you have read this chapter closely, you should try to think of ways in which you can apply the information it contains to your technical duties as an Equipment Operator Third or Second.

As far as technical qualifications are concerned, the Equipment Operator petty officer must possess the leadership qualities required to train and supervise a crew of subordinates who are capable of producing, under his supervision, construction work of the first quality, performed in accordance with drawings and specifications, and completed on or ahead of schedule. As an Equipment Operator Third your crews will be small; they will increase in size as you rise through the rates, until as a Chief Equipment Operator, you may have the final enlisted responsibility for a large earthmoving or asphalt paving job.

As is the case with practically any type of technical leadership, the first and most essential requirement is the possession of a vast amount of technical knowledge and technical skill. Along with this must go the capacity for extending this knowledge and skill to subordinates, plus the ability to organize both the job and the men in the manner which will best expedite the work and develop each man's particular knowledge and skill.

An indispensable part of leadership, is the development of confidence and respect of your subordinates, which are in turn to a large extent founded upon their opinion of your own technical capacities.

ADVANCEMENT

Some of the rewards of advancement are easy to see. You get more pay. You job assignments become more interesting and more challenging. You are regarded with greater respect by officers and enlisted personnel. You enjoy the satisfaction of getting ahead in your chosen Navy career.

But the advantages of advancement are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By each advancement, you increase your value to the Navy in two ways. First, you become more valuable as a specialist in your own rating, and second, you become more valuable as a person who can train others and thus make far-reaching contributions to the entire Navy.

HOW TO QUALIFY FOR ADVANCEMENT

What must you do to qualify for advancement? The requirements may change from time to time, but usually you must:

1. Have a certain amount of time in your present grade.
2. Complete the required military and rating manuals.

3. Demonstrate your ability to perform all those PRACTICAL requirements applicable to the rate for which you are striving and have them checked off on the Record of Practical Factors, NAVPERS 1414/1.

4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they consider you capable of performing the duties of the next higher rate.

5. Demonstrate your KNOWLEDGE by passing written examinations on the occupational and military qualification standards for advancement.

Some of these general requirements may be modified in certain ways. Figure 1-1 gives a more detailed view of the requirements for advancement of active duty personnel; figure 1-2 gives this information for inactive duty personnel.

Remember that the qualifications for advancement can change. Check with your division officer or training officer to be sure that you know the most recent qualifications.

Advancement is not automatic. Even though you have met all the requirements, including passing the written examinations, you may not be able to "sew on the crow" or "add a stripe." The number of men in each rate and rating is controlled on a Navywide basis. Therefore, the number of men who may be advanced is limited by the number of vacancies that exist. When the number of men passing the examination exceeds the number of vacancies, some system must be used to determine which men may be advanced and which may not. The system used is the "final multiple" and is a combination of three types of advancement systems.

Merit rating system
Personnel testing system
Longevity, or seniority system

The Navy's system provides credit for performance, knowledge, and seniority, and, while it cannot guarantee that any one person will be advanced, it does guarantee that all men within a particular rating will have equal advancement opportunity.

The following factors are considered in computing the final multiple.

MAX POINTS	FACTOR	WEIGHT
80	Examination Score	40%
50	Performance (Average of marks received)	25%
20	Total Active Service (1 per yr)	10%
20	Time in Present Grade (2 per yr)	10%
15	Medals and Awards	7.5%
15	PNA (Maximum 3 per cycle)	7.5%
200 (MAX POSSIBLE)		100%

All of the above information (except the examination score and the PNA factor) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, and the PNA points (additional points awarded to those who previously passed the examination but were not advanced) are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vacancies.

PNA FACTOR

PNA points are comprised of two subfactors, Navy-wide examination score and performance mark standing. Individually, both subfactors are weighed in relation to a member's standing among all those who participated in his specific examination rate for a given cycle. In the case of the performance mark standing subfactor, individual performance mark averages submitted to the Naval Examining Center are used as the basis for determining the member's performance standing in relation to his contemporaries. For those who pass examinations but are not advanced, additional points will be credited to their final multiple for succeeding examinations in accordance with the schedule established for each subfactor as follows:

REQUIREMENTS *	E1 to E2	E2 to E3	# E3 to E4	#† E4 to E5	† E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service- or completion of Recruit Training.	8 mos. as E-2.	6 mos. as E-3.	12 mos. as E-4.	24 mos. as E-5.	36 mos. as E6. 8 years total enlisted service.	36 mos. as E-7. 8 of 11 years total service must be enlisted.	24 mos. as E-8. 10 of 13 years total service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)		Class A for PR3, DT3, PT3, AME 3, HM 3, PN 3, FTB 3, MT 3,			Class B for AGC, MUC, MNC.††		
PRACTICAL FACTORS	Locally prepared check-offs.	Record of **Practical Factors**, NavPers 1414/1, must be **completed for E-3** and all PO advancements.						
PERFORMANCE TEST			**Specified ratings** must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS **	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.				Navy-wide, selection board.	
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavTra 10052 (current edition).					Correspondence courses and recommended reading. See NavTra 10052 (current edition).	
AUTHORIZATION	Commanding Officer		Naval Examining Center					

* All advancements require commanding officer's recommendation.
† 1 year obligated service required for E-5, and E-6; 2 years for E-7, E-8, and E-9.
# Military leadership exam required for E-4 and E-5.
** For E-2 to E-3, NAVEXAMCEN exams or locally prepared tests may be used.
†† Waived for qualified EOD personnel.

Figure 1-1. – Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	8 mos.	6 mos.	12 mos.	24 mos.	36 mos. with total 8 yrs service	36 mos. with total 11 yrs service	24 mos. with total 13 yrs service
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS			Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavPers 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO advancements. Also pass Military Leadership Exam for E-4 and E-5.				Standard Exam, Selection Board.	
AUTHORIZATION	Commanding Officer		Naval Examining Center					

*Recommendation by commanding officer required for all advancements.
† Active duty periods may be substituted for training duty.

Figure 1-2. — Inactive duty advancement requirements.

EXAMINATION SCORE	POINTS
70 through 80	1.5
60 through 69	1.0
Passing through 59	.5

PERFORMANCE MARK AVERAGE	POINTS
Top 25 Percent	1.5
Upper 25 to 50 Percent	1.0
Lower 50 to 25 Percent	.5
Bottom 25 Percent	.0

NOTE: Maximum of 3 multiple points per cycle. Maximum of 15 multiple points after 5 exam cycles.

PNA points will be awarded as follows: A maximum of three points can be accrued each examination cycle. After five examination cycles, candidates will be eligible for the maximum number of points (15). Subsequent to complete implementation, each candidate's PNA factor will be computed based on the points received in the five most recent examinations competed in, out of the last six examinations. This will allow candidates to miss one examination and still be eligible for the maximum award.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, work on the practical factors, study the required rate training manuals, and study other material that is required for advancement in your rating. To prepare for advancement, you will need to be (1) familiar with the quals manual, (2) Complete the Record of Practical Factors, (3) refer to NAVTRA publication called Bibliography for Advancement Study, NAVTRA 10052, and (4) complete applicable rate training manuals. The following sections describe each of these and give you some practical suggestions on how to use them in preparing for advancement.

Quals Manual

The Manual of Qualifications for Advancement, NAVPERS 18068C, gives the minimum occupational and military qualification standards for advancement to each pay grade within each rating. This manual is usually called the "Quals Manual," and the qualifications themselves are often called "quals." The qualification standards are of two general types: (1) military qualification standards and (2) occupational qualification standards.

MILITARY QUALIFICATIONS STANDARDS are requirements that apply to all ratings rather than to any one particular rating. Military requirements for advancement to third class and second class petty officer rates deal with military conduct and readiness, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all ratings.

OCCUPATIONAL QUALIFICATION STANDARDS are requirements that are directly related to the work of each rating.

Both the military requirements and the occupational qualification standards are divided into subject matter groups; then, within each subject matter group, they are divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS. Practical factors are things you must be able to DO. Knowledge factors are things you must KNOW in order to perform the duties of your rating.

In most subject matter areas, you will find both practical factor and knowledge factor qualifications. In some subject matter areas, you may find only one or the other. It is important to remember that there are some knowledge aspects to all practical factors, and some practical aspects to most knowledge factors. Therefore, even if the quals manual indicates that there are no knowledge factors for a given subject matter area, you may still expect to find examination questions dealing with the knowledge aspects of the practical factors listed in that subject matter area.

You are required to pass a Navywide military/leadership examination for E-4 or E-5, as appropriate, before you take the occupational examinations. The military/leadership examinations are administered on a schedule determined by your commanding officer. Candidates are required to pass the applicable military/leadership examination only once. Each of these examinations consists of 100 questions based on information contained in Military Requirements for Petty Officers 3 & 2, NAVPERS 10056 and other publications listed in Bibliography for Advancement Study, NAVTRA 10052.

The Navywide occupational examinations for pay grades E-4 and E-5 will contain 150 questions related to occupational areas of your rating.

If you are working for advancement to second class, remember that you may be examined on third class qualifications as well as on second class qualifications.

The quals manual is kept current by means of changes. The occupational qualifications for your rating which are covered in this training manual were current at the time the manual was printed. By the time you study this manual, however, the quals for your rating may have been changed. Never trust any set of quals until you have checked it against an UP-TO-DATE quals manual.

Record of Practical Factors

Before you can take the servicewide examinations for advancement, there must be an entry in your service record to show that you have qualified in the practical factors of both the military and the occupational qualifications. The RECORD OF PRACTICAL FACTORS, mentioned earlier, is used to keep a record of your practical factor qualifications. This form is available for each rating. The form lists all practical factors, both military and occupational. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns.

Changes are made periodically to the Manual of Qualifications for Advancement, and revised forms of NAVPERS 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the quals manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement.

Until completed, the NAVPERS 1414/1 is usually held by your division officer; after completion, it is forwarded to the personnel office for insertion in your service record. If you are transferred before qualifying in all practical factors, the incomplete form should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form actually is inserted in your service record before you are transferred. If the form is not in your service record, you may be required to start all over again and requalify in the practical factors which have already been checked off.

NAVTRA 10052

The Bibliography for Advancement Study, NAVTRA 10052 (revised), is a very important publication for any enlisted person preparing for advancement. This bibliography lists required and recommended rate training manuals and other reference material to be used by personnel working for advancement.

NAVTRA 10052 is revised and issued once each year by the Naval Training Support Command. Each revised edition is identified by a letter following the number. When using this publication, be SURE that you have the most recent edition.

If extensive changes in qualifications occur in any rating between the annual revisions of NAVTRA 10052, a supplementary list of study material may be issued in the form of a NAVTRA Notice. When you are preparing for advancement, check to see whether changes have been made in the qualifications for your rating. If changes have been made, see if a NAVTRA Notice has been issued to supplement NAVTRA 10052 for your rating.

The required and recommended references are listed by pay grade in NAVTRA 10052. If you are working for advancement to third class, study the material that is listed for third class. If you are working for advancement to second class, study the material that is listed for second class; but remember that you are also responsible for the references listed at the third class level.

In using NAVTRA 10052 you will notice that some rate training manuals are marked with an asterisk(*). Any manual marked in this way is MANDATORY—that is, it must be completed at the indicated rate level before you can be eligible to take the servicewide examination for advancement. Each mandatory manual may be completed by (1) passing the appropriate enlisted correspondence course that is based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the training manual; or (3) in some cases, successfully completing an appropriate Navy school.

Do not overlook the section of NAVTRA 10052 which lists the required and recommended references relating to the military qualification standards for advancement. Personnel of ALL ratings must complete the mandatory military requirements training manual for the appropriate level before they can be eligible to advance.

The references in NAVTRA 10052 which are recommended but not mandatory should also be studied carefully. ALL references listed in NAVTRA 10052 may be used as source material for the written examinations, at the appropriate rate levels.

Rate Training Manuals

There are two general types of rate training manuals. RATING manuals (such as this one) are prepared for most enlisted ratings. A rating manual gives information that is directly related to the occupational qualifications of ONE rating. SUBJECT MATTER manuals or BASIC manuals give information that applies to more than one rating.

Rate training manuals are revised from time to time to keep them up to date technically. The revision of a rate training manual is identified by a letter following the NAVTRA number. You can tell whether any particular copy of a training manual is the latest edition by checking the NAVTRA number and the letter following this number in the most recent edition of List of Training Manuals and Correspondence Courses, NAVTRA 10061. NAVTRA 10061 is actually a catalog that lists all current training manuals and correspondence courses (you will find this catalog useful in planning your study program.)

Each time a rate training manual is revised, it is brought into conformance with the official publications and directives on which it is based; but during the life of any edition, discrepancies between the manual and the official sources are almost certain to arise because of changes to the latter which are issued in the interim. In the performance of your duties, you should always refer to the appropriate official publication or directive. If the official source is listed in NAVTRA 10052, the Naval Examining Center uses it as a source of questions in preparing the fleetwide examinations for advancement. In case of discrepancy between any publications listed in NAVTRA 10052 for a given rate, the Examining Center will use the most recent material.

Rate training manuals are designed to help you prepare for advancement. The following suggestions may help you to make the best use of this manual and other Navy training publications when you are preparing for advancement.

1. Study the military and the occupational qualifications for your rating before you study the training manual, and refer to the quals frequently as you study. Remember, you are studying the manual primarily in order to meet these quals.
2. Set up a regular study plan. It will probably be easier for you to stick to a schedule if you can plan to study at the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.
3. Before you begin to study any part of the manual intensively, become familiar with the entire book. Read the preface and the table of contents. Check through the index. Look at the appendixes. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.
4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book. As you look through the book in this way, ask yourself such questions as:

- What do I need to learn about this?
- What do I already know about this?
- How is this information related to information given in other chapters?
- How is this information related to the qualifications for advancement?

5. When you have a general idea of what is in the training manual and how it is organized,

fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use enlisted correspondence courses whenever you can. The correspondence courses are based on rate training manuals or on other appropriate texts. As mentioned before, completion of a mandatory rate training manual can be accomplished by passing an enlisted correspondence course based on the rate training manual. You will probably find it helpful to take other correspondence courses as well as those based on mandatory manuals. Taking a correspondence course helps you to master the information given in the training manual, and also helps you see how much you have learned.

10. Think of your future as you study rate training manuals. You are working for advancement to third class or second class right now, but some day you will be working toward higher rates. Anything extra that you can learn now will help you both now and later.

SOURCES OF INFORMATION

Besides training manuals, NAVTRA 10052 lists official publications on which you may be examined. Make sure you study the sections required.

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the occupational qualifications of your rating.

Some publications are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying canceled or obsolete information will not help you to do your work or to advance; it is likely to be a waste of time, and may even be seriously misleading.

GOVERNMENT PUBLICATIONS

There are various government publications which you may find useful as sources of reference. A number of publications issued by the Naval Facilities Engineering Command (NAVFAC) which will be of interest to personnel in the Group VIII ratings are listed in the Index of Naval Facilities Engineering Command Publications, NAVFAC P-349 (updated semiannually). A publications program is one of the principal communications media used by NAVFAC to provide a ready reference of current technical and administrative data for use by its subordinate units. NAVFAC publications are listed in alphabetical and numerical order in NAVFAC P-349; copies of NAVFAC P-349 may be obtained through proper channels from the U.S. Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

Some of the training publications that you will need to study or refer to as you prepare for advancement have already been discussed earlier in this chapter. Two additional publications that you may find useful are listed below.

Tools and Their Uses, NavPers 10085
Blueprint Reading and Sketching, NavPers 10077

In addition, you may find it useful to consult the rate training manuals prepared for other Group VIII (Construction) ratings. Reference to these manuals will add to your knowledge of the duties of other men in the Construction ratings.

Some of the U.S. Army technical manuals (TMs) may contain information that will help you in your work. TMs are easily ordered through the normal naval supply procurement system.

COMMERCIAL PUBLICATIONS

A wealth of information of concern to persons in the construction field is contained in reports, pamphlets, handbooks, and texts published by manufacturers, trade associations, technical and professional societies, and commercial publishing houses. Much of this literature will be available to you at the station library, the Public Works Department, or the battalion operations office or technical library.

DESIGNATION OF SOURCE, SUBJECT AND EDITION

Official publications and directives carry abbreviations and numbers which identify the source of the document and its subject matter. This training manual, for instance, is NAVTRA 10640-G, which means that it is a publication of the Naval Training Support Command, a rate training manual in the Group VIII rating structure. The letter following the numerals designates the edition (the date of publication is printed on the Preface page). Because you should always make it your responsibility to see that you are using the latest edition of any publication or directive, we usually do not show the final letter when referring to a publication or directive in this training manual. ALWAYS USE THE LATEST EDITION.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Training films are listed in the United States Navy Film Catalog, NAVAIR 10-1-777 (formerly NAVWEPS 10-1-777), published in 1971. Copies may be ordered in accordance with the Navy Stock List of Forms and Publications, NAVSUP 2002. Supplements to the Film Catalog are issued as appropriate.

When selecting a film, note its date of issue listed in the Film Catalog. As you know, procedures sometimes change rapidly. Thus some films become obsolete rapidly. If film is obsolete only in part, it may sometimes be shown effectively if before or during its showing you carefully point out to trainees the procedures that have changed.

CHAPTER 2

ADMINISTRATIVE DUTIES AND SAFETY RESPONSIBILITIES

As an EO, you still have a great deal to learn about your trade, including the development of skills required in performing tasks concerning equipment operation and maintenance. And from time to time you will be called upon to fill the role of a supervisor. Your duties and responsibilities as a supervisor will be limited, but they will gradually increase as you advance from one pay grade to the next. This chapter discusses two major responsibilities of concern to supervisors—administration and safety. It is not intended to tell you all you need to know about these two subjects, but to give you some idea of what you, as an EO3 or EO2, can expect in the way of administrative duties and safety responsibilities. As part of this chapter, information also is included on Navy Enlisted Classification Codes (NECs) available to EOs and the purpose of the Personnel Readiness Capability Program.

ASSIGNMENT AS CREW LEADER

As you gain experience in construction work, you will probably be called upon to serve as crew leader of EO teams (or crews) consisting of 3 to 5 men. These teams perform various types of work. They may be assigned, for instance, to a portable rotary well drilling rig requiring a three-man crew, consisting of a driller and two helpers. The driller has charge of all operations, and is responsible for the care and maintenance of the equipment. The helpers keep the settling pit clean, maintain an adequate water supply, keep fuel and water in the engine, and lubricate and service the equipment. When the drill pipe is being run in or out of the hole, one helper works on the ground and helps the driller break the joints. He sets the slips, screws the hoisting plug in and out, and helps set the drill pipes in place. The other helper works on the mast platform. He screws and unscrews the hoisting plug and helps handle the drill pipes.

Your duties as a crew leader will vary from one activity to another. At most activities, however, a crew leader's duties may involve planning work assignments, supervising work teams, initiating requisitions, and keeping time cards. Information that will aid you in carrying out these duties is given below.

PLANNING WORK ASSIGNMENTS

Planning is the process of determining requirements and devising and developing methods and schemes of action for construction of a project. Proper planning saves time and money for the Navy and makes the job easier for all concerned. The following pointers will aid you in planning day-to-day work assignments for work teams.

When you are assigned a job, whether in writing or orally, one of the first things to do is to make sure you understand clearly just what is to be done. Study plans and specifications where applicable. If you have any questions, find out the answers from those in a position to supply the information you need. Among other things, make sure you understand the priority of the project, time of completion, and any special instructions to be followed.

In planning for a small or large project, you must consider the capability of the men available for assignment. Determine who is to do what and how long it should take to complete the job. Realizing that idleness may breed discontent, arrange to have another job ready for starting as soon as the first one is finished.

Establish goals for each work day and encourage your men to work together as a team in accomplishing these goals. You want your goals to be such that your men will be kept busy, but make sure they are realistic. During an emergency, most men will make a tremendous effort to meet the deadline. But men are not machines, and when there is no emergency, they cannot be expected to continuously achieve an excessively high rate of production. In your planning, you must also allow for things which are not considered as direct labor, such as safety training, disaster control training, leave, and liberty.

To help ensure that the job is done properly and on time, you will want to consider the method to use in accomplishing the job. If there is more than one way of doing a particular job, make sure the method you select is the best way. After selecting a method, analyze it to see if it could be simplified with a resultant savings in time and effort.

Plan material requirements so that you will not have a lot of materials left over. But don't have your material estimate so low that you may run out of necessary items and delay the job so that your men mav remain idle, until more materials can be obtained. At times, circumstances come about that make it necessary to use more materials than anticipated.

Consider the tools and equipment you will need for the job and arrange to have them available at the place where the work is to be done, and at the time the work is to get underway. Determine who will use the tools, and make sure the men to whom they are assigned know how to use them properly and safely. Plan to have the materials so that they will be in an accessible place but not pose a safety hazard.

SUPERVISING WORK TEAMS

After a job has been properly planned, it is necessary to supervise the job carefully to ensure that it is completed properly and on time. Some pointers that will aid you in supervising work teams are given below.

Prior to starting a job, make sure your men know what is to be done. Give instructions clearly, and urge your men to ask questions on any points that are not clear to them. Be sure the men know all pertinent safety precautions and wear safety apparel where required.

While the job is underway, check from time to time to ensure that the work is progressing satisfactorily. Determine if the proper methods, materials, tools and equipment are being used. If a man is doing a job wrong, stop him and point out what he is doing wrong. Then explain the correct procedure and check to see that he follows it. In checking the work of your men, try and do it in such a way that your men will feel that the purpose of your inspection is to teach, guide and direct, rather than to criticize and find fault.

The supervisor should make sure that his men observe all applicable safety precautions. He should also watch for hazardous conditions, improper use of tools and equipment, and unsafe work practices which could cause accidents and possibly result in injury to personnel. Many young men are heedless of danger, or think a particular regulation is unnecessary. Very often such persons get hurt.

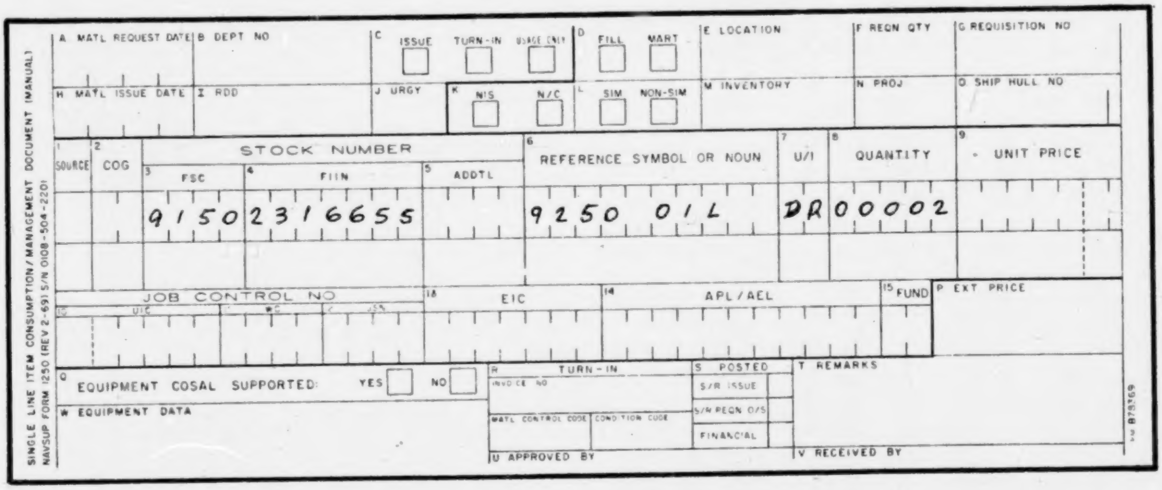
When time permits, rotate the men on various jobs. Rotation gives them varied experience and will help ensure your having men who can do the work if someone is hospitalized, transferred, or goes on leave.

A good supervisor should be able to get others to work together in getting the job accomplished. He should maintain an approachable attitude towards his men, making them feel free to come and seek his advice when in doubt as to any phase of the project. Emotional balance is especially important; a supervisor cannot become panicky before his men, unsure of himself in the face of conflicting forces, or pliable with influence. He should use tact and courtesy in dealing with his men and not show partiality to certain members of the work team. He should keep his men informed on matters that affect them personally or concern their work. He should also seek to maintain a high level of morale, keeping in mind that low morale can have a definite effect upon the quantity and quality of work turned out by his men.

The above is only a brief treatment on the subject of supervision. As you advance in rate you will be spending more and more of your time in supervising others, so let us urge that you make a continuing effort to learn more about the subject. Study books on supervision as well as leadership. Also, read articles on topics of concern to supervisors — such as safety, training, job planning, etc. — that appear from time to time in trade journals and other publications. There is a big need in the Navy for petty officers who are skilled supervisors. So, consider the role as supervisor a big challenge and endeavor to become proficient in all areas of the supervisor's job.

PREPARING REQUISITIONS

As a crew leader, you must be able to prepare requisitions, which are orders from one activity requesting material or service from another activity. The most common method of requisitioning involves the use of printed forms which are designed to provide all necessary information



SINGLE LINE ITEM CONSUMPTION/MANAGEMENT DOCUMENT (MANUAL)
NAVSUP FORM 1250 (REV 2-69) S/N 0108-504-2201

A MATL REQUEST DATE
B DEPT NO
C ISSUE ☐ TURN-IN ☐ USAGE ONLY ☐
D FILL ☐ MART ☐
E LOCATION
F REQN QTY
G REQUISITION NO
H MATL ISSUE DATE
I RDD
J URGY
K NIS ☐ N/C ☐
L SIM ☐ NON-SIM ☐
M INVENTORY
N PROJ
O SHIP HULL NO

1 SOURCE	2 COG	STOCK NUMBER 3 FSC	STOCK NUMBER 4 FIIN	STOCK NUMBER 5 ADDTL	6 REFERENCE SYMBOL OR NOUN	7 U/I	8 QUANTITY	9 UNIT PRICE
		9150	2316655		9250 OIL	DR	00002	

JOB CONTROL NO: 10 UIC, 11 WC, 12 JSN
13 EIC
14 APL/AEL
15 FUND
P EXT PRICE
Q EQUIPMENT COSAL SUPPORTED: YES ☐ NO ☐
R TURN-IN: INVOICE NO; MATL CONTROL CODE; CONDITION CODE
S POSTED: S/R ISSUE; S/R REQN O/S; FINANCIAL
T REMARKS
W EQUIPMENT DATA
U APPROVED BY
V RECEIVED BY

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Figure 2-1.—Single Line Item Consumption/Management Document (manual); NavSup Form 1250.

for physical transfer of the material and accounting requirements.

Two forms used for requisitioning materials are the Single Line Item Consumption/Management Document (Manual), NAVSUP Form 1250 (fig. 2-1) and the Requisition and Invoice/Shipping Document, DD Form 1149 (fig. 2-2).

As a crew leader, you are not usually required to make up the entire NAVSUP Form 1250; however, you must list the item's stock number (when available), quantity, and reference symbol or name of each item needed. This form (NAVSUP Form 1250) is turned in to the expediter who will check it over, completing the other information, sign and then forward it to the Material Liaison Officer (MLO) or Supply Department for processing.

You are not likely to use DD Form 1149 very often. The items most frequently ordered on DD Form 1149 are bulk fuels and lubricants. This form is limited to a single page and must contain no more than nine line items. DD Form 1149 has many uses. It is not necessary to fill in all the blocks when this form is used as a requisition.

In requisitioning material you will need to know about the Federal Supply Classification (FSC) system. Information on the FSC system and other topics relating to supply is given in Military Requirements for Petty Officer 3&2, NAVPERS 10056-C. If necessary, review material on supply in NAVPERS 10056-C before going on to the next chapter.

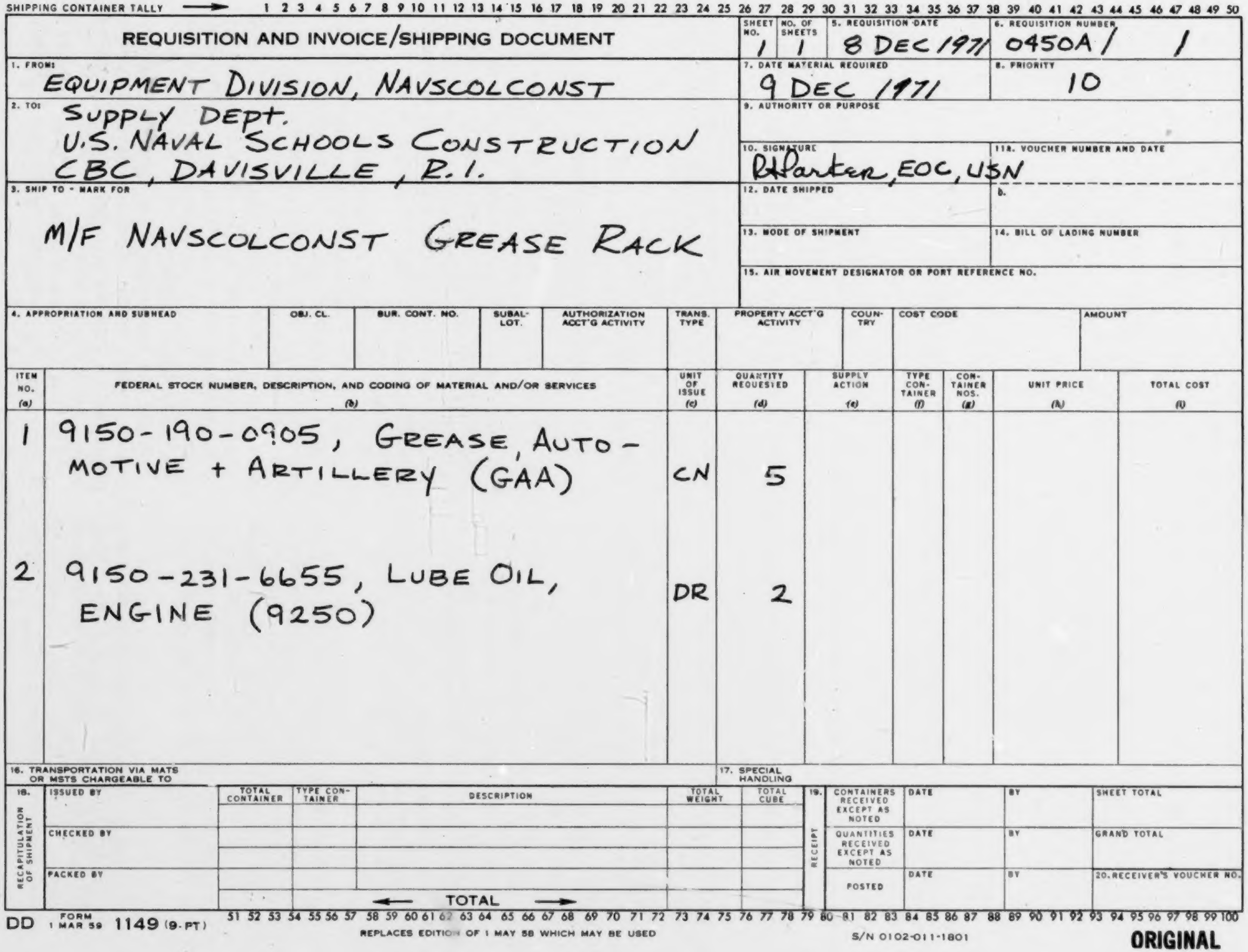
TIMEKEEPING

Your duties as an EO may involve the posting of entries on time cards for both military and civilian personnel. Therefore, you should know the types of information called for on time cards and understand the importance of accuracy in labor reporting. Here, we are primarily interested in the labor reporting system used in the battalion. You will find, however, that the system employed at shore-based activities is similar to that used in the battalion.

In order to record and measure the number of man-hours the unit spends on various functions, a labor accounting system is mandatory. This system must permit the day-by-day accumulation of labor utilization data in sufficient detail and in a manner that allows ready compilation of information required by the Operations Officer in the management of the manpower resources. It also aids in the preparation of the various reports to higher authority.

While the system may vary slightly from one unit to another, they are so similar that the one described in this manual can be considered as being typical for all units.

The unit must account for all labor expended in carrying out assigned tasks and functions.



SHIPPING CONTAINER TALLY ⟶ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO. 1
NO. OF SHEETS 1
5. REQUISITION DATE 8 DEC 1971
6. REQUISITION NUMBER 0450A / 1

1. FROM: EQUIPMENT DIVISION, NAVSCOLCONST
7. DATE MATERIAL REQUIRED 9 DEC 1971
8. PRIORITY 10

2. TO: SUPPLY DEPT.
U.S. NAVAL SCHOOLS CONSTRUCTION
CBC, DAVISVILLE, R.I.

9. AUTHORITY OR PURPOSE
10. SIGNATURE RHarter, EOC, USN
11a. VOUCHER NUMBER AND DATE
b.
12. DATE SHIPPED

3. SHIP TO - MARK FOR
M/F NAVSCOLCONST GREASE RACK

13. MODE OF SHIPMENT
14. BILL OF LADING NUMBER
15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.

4. APPROPRIATION AND SUBHEAD	OBJ. CL.	BUR. CONT. NO.	SUBAL-LOT.	AUTHORIZATION ACCT'G ACTIVITY	TRANS. TYPE	PROPERTY ACCT'G ACTIVITY	COUN-TRY	COST CODE	AMOUNT

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CON-TAINER (f)	CON-TAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
1	9150-190-0905, GREASE, AUTO-MOTIVE + ARTILLERY (GAA)	CN	5					
2	9150-231-6655, LUBE OIL, ENGINE (9250)	DR	2					

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO
17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT	TOTAL CONTAINER	TYPE CON-TAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
ISSUED BY					
CHECKED BY					
PACKED BY					
			⟵ TOTAL ⟶		

19. RECEIPT			
CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL
POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.

DD FORM 1 MAR 59 1149 (9-PT) 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 58 WHICH MAY BE USED

S/N 0102-011-1801

ORIGINAL

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Figure 2-2.—Requisition and Invoice/Shipping Document, DD Form 1149.

This accounting must include the work performed by the reporting unit and, when applicable, work performed by civilian labor and the military personnel of other activities. Labor expenditures must be accumulated under a number of reporting categories. This degree of reporting detail is required to provide the management data necessary to determine labor expenditures on project work for calculation of statistical labor costs, and comparison of actual construction performance with estimating standards. It also serves to determine the effectiveness of labor utilization in performing administrative and support functions, both for internal unit management and for development of planning standards by higher command.

For timekeeping and labor reporting purposes, total labor is considered as being either in one of two categories, i.e., productive or overhead. PRODUCTIVE LABOR includes all labor that directly or indirectly contributes to accomplishment of the unit's mission, including construction operations, military operations, and training. Productive labor is accounted for in two categories: direct and indirect labor.

1. DIRECT LABOR includes all labor expended directly on assigned construction tasks, either in the field, or in the shop, and that which contributes directly to the completion of the end product. Direct labor must be reported separately for each assigned construction item.
2. INDIRECT LABOR comprises labor required to support construction operations, but which does not produce an end product itself.

OVERHEAD LABOR is not considered to be productive labor in that it does not contribute directly or indirectly to the end product. It includes all labor that must be performed regardless of the assigned mission.

During the planning and scheduling of a construction project, each phase of the project considered as direct labor is given an identifying code, usually by the Operations Department. For example, "clearing and grubbing of site" may be assigned code R-15, "trenching" R-16, and "pipe laying" R-17. Due to the many types of construction projects encountered and different operations involved, codes for direct labor reporting may vary widely from one activity to another. The crew leader uses direct labor codes in reporting the hours spent by each member of his crew during each work day on assigned construction task.

Codes also are used to report time spent by crew members in the following categories: indirect labor, military operations and readiness, disaster control operations, training, and overhead labor. You will find the codes shown in figure 2-3 used at most activities to indicate time spent in these categories.

The crew leader's report is submitted on a daily labor distribution report form such as that shown in figure 2-4. The report is prepared by the crew leader for each phase of the construction project that his crew is involved with, and immediately provides a breakdown by man-hours of the activities in the various labor codes for each man in the crew for any given day on any given project. It should be reviewed at the company level by the Platoon Commander, The Assistant Company Commander, and the Company Commander, and should be initialed by the Company Commander before it is forwarded to the Operations Department. It will be tabulated by the Management Division of the Operations Department, along with all of the daily labor distribution reports received from each company and department in the unit. It serves as the means by which the Operations Officer analyzes the labor distribution of his total manpower resources for any given day, and as feeder information for the preparation of the monthly operations report, and any other resource reports required of the unit.

Bear in mind that this information must be accurate and timely, and that each level in the company organization should review it for an analysis of its own internal construction management and performance, rather than having it serve merely as a feeder report to the Operations Officer.

SAFETY DUTIES OF SUPERVISORY PERSONNEL

Safety is a matter of chief concern to every supervisor. The supervisor who can continuously boast an outstanding safety record for his shop or field work team has a lot to be proud of. Safety precautions relating to specific operations performed by the EO are presented in various portions of this training manual. In this discussion, we are concerned with the safety organization of a mobile construction battalion, safety training responsibilities of a Crew Petty Officer, and the reporting procedures which the Crew Petty Officer must carry out if a subordinate

PRODUCTIVE LABOR. Productive labor includes all labor that directly contributes to the accomplishment of the Naval Mobile Construction Battalion, including construction operations and readiness, disaster recovery operations, and training.

DIRECT LABOR. This category includes all labor expended directly on assigned construction tasks, either in the field or in the shop, and which contributes directly to the completion of the end product.

INDIRECT LABOR. This category comprises labor required to support construction operations, but which does not produce in itself. Indirect labor reporting codes are as follows:

- X01 Construction Equipment Maintenance, Repair and Records
- X02 Operation and Engineering
- X03 Project Supervision
- X04 Project Expediting (Shop Planners)
- X05 Location Moving
- X06 Project Material Support
- X07 Tool and Spare Parts Issue
- X08 Other

MILITARY OPERATIONS AND READINESS. This category comprises all manpower expended in actual military operations, unit embarkation, and planning and preparations necessary to insure unit military and mobility readiness. Reporting codes are as follows:

- M01 Military Operations
- M02 Military Security
- M03 Embarkation
- M04 Unit Movement
- M05 Mobility Preparation
- M06 Contingency
- M07 Military Administrative Functions
- M08 Mobility & Defense Exercise
- M09 Other

DISASTER CONTROL OPERATIONS

- D01 Disaster Control Operations
- D02 Disaster Control Exercise

TRAINING. This category includes attendance at service schools, factory and industrial training courses, fleet type training, and short courses, military training, and organized training conducted within the battalion. Reporting codes are as follows:

- T01 Technical Training
- T02 Military Training
- T03 Disaster Control Training
- T04 Leadership Training
- T05 Safety Training
- T06 Training Administration

OVERHEAD LABOR. This category includes labor which must be performed regardless of whether a mission is assigned, and which does not contribute to the assigned mission. Reporting codes are as follows:

- Y01 Administrative & Personnel
- Y02 Medical & Dental Department
- Y03 Navy Exchange and Special Services
- Y04 Supply & Disbursing
- Y05 Commissary
- Y06 Camp Upkeep & Repairs
- Y07 Security
- Y08 Leave & Liberty
- Y09 Sickcall, Dental & Hospitalization
- Y10 Personal Affairs
- Y11 Lost Time
- Y12 TAD not for unit
- Y13 Other

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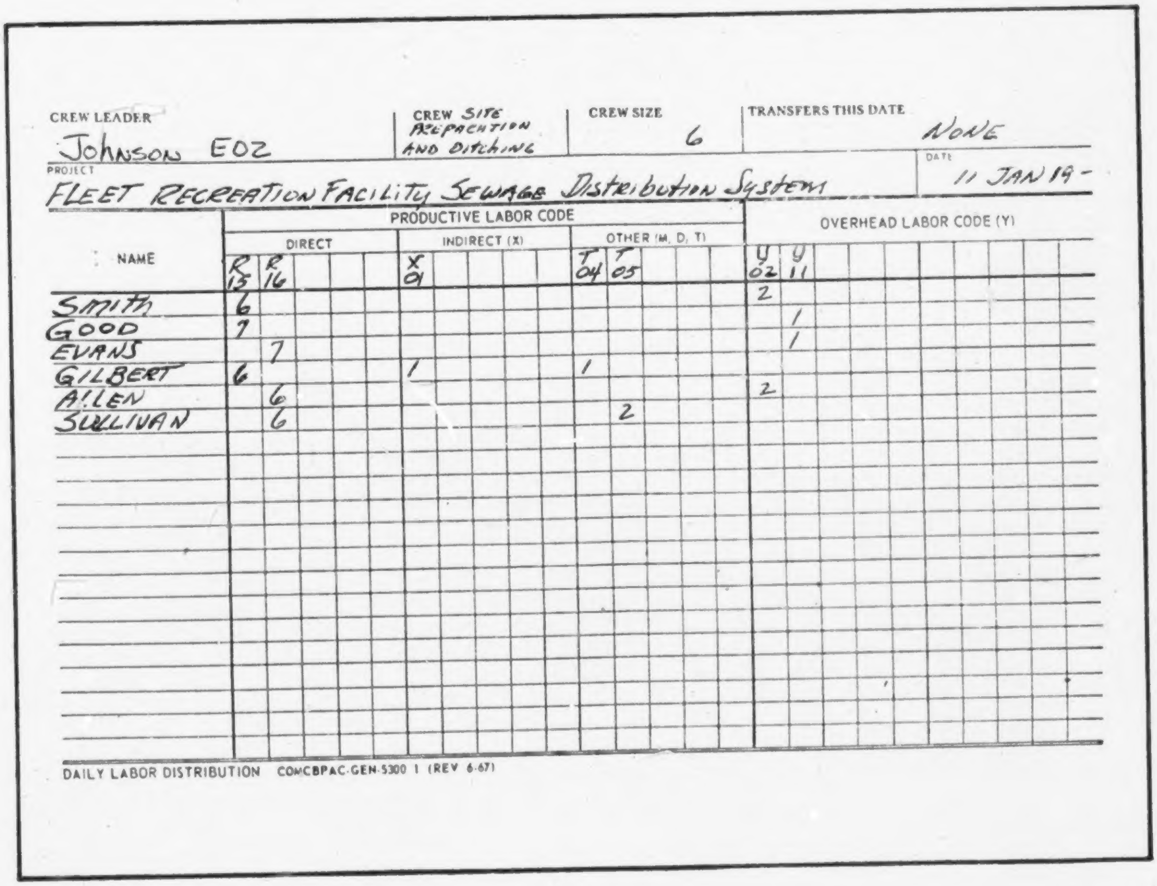
Figure 2-3.—Sub-categories of labor.



CREW LEADER Johnson EO2
CREW SITE PREPARATION AND DITCHING
CREW SIZE 6
TRANSFERS THIS DATE NONE
PROJECT FLEET RECREATION FACILITY SEWAGE DISTRIBUTION SYSTEM
DATE 11 JAN 19-

	PRODUCTIVE LABOR CODE															OVERHEAD LABOR CODE (Y)									
	DIRECT					INDIRECT (X)					OTHER (M, D, T)														
NAME	R 15	R 16				X 01					T 04	T 05				Y 02	Y 11								
SMITH	6															2									
GOOD	7																1								
EVANS		7															1								
GILBERT	6					1					1														
ALLEN		6														2									
SULLIVAN		6										2													

DAILY LABOR DISTRIBUTION COMCBPAC-GEN-5300 1 (REV 6-67)

54.309

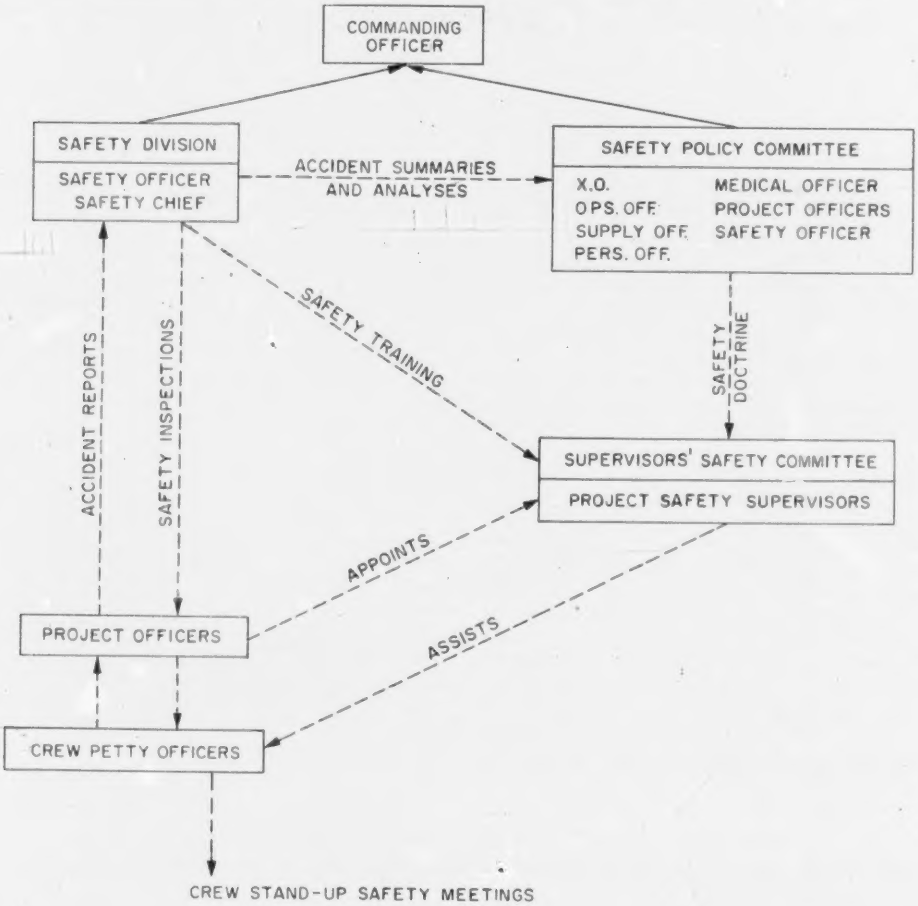
Figure 2-4.—Daily labor distribution report form.

is involved in an accident. Although these responsibilities may seem somewhat distant now, the sooner you start thinking about them, the better prepared you will be when it comes time to assure them. If you are an EO3 studying for advancement to EO2, then you can reasonably expect to assume these duties in the near future.

BATTALION SAFETY ORGANIZATION

As a supervisor in a mobile construction battalion, you should have a knowledge of the safety organization of the battalion. This is important since you cannot function as a Crew Petty Officer in an intelligent and informed manner unless you are aware of how you fit into the battalion's scheme of safety. In other words, you should know who (or what group) in the battalion arbitrates and establishes the safety policies and procedures you must follow. You should also know who will be your source of safety guidance in training and supervising your men. In addition, you should know to whom your accident reports involving accidents to men are routed, and more importantly, why this information is sought.

Every mobile construction battalion is required by COMCBLANT/COMCBPAC instructions to implement a formal safety organization (see



2.223(127E)

Figure 2-5. — NMCB safety organization.

figure. 2-5). The two principal agencies of this organization are the Safety Policy Committee and the Safety Division.

The SAFETY POLICY COMMITTEE is presided over by the Executive Officer and includes among its members the Operations Officer, Supply Officer, Personnel Officer, Medical Officer, Safety Officer, and any other members which the Commanding Officer may wish to appoint. As its name suggests, the primary purpose of the committee is to formulate safety doctrine and policy for the battalion. In order to do this, the committee must continually review and evaluate the work practices of the battalion, particularly in the light of accident analyses and reports, so as to be able to recommend practical and effective safety precautions.

The SAFETY DIVISION is detailed to ensure that the procedures established through the Safety Policy Committee are carried out properly and expeditiously throughout the battalion. The Safety Division is normally composed of the Safety Officer and the Safety Inspector (more commonly known as the Safety Chief), and whatever additional assistants are necessary. The position of Safety Officer is a collateral duty, assigned to an officer by the Commanding Officer and under the direct supervision and control of the Operations Officer. Safety Chief, is a full-time position assigned to a Chief Petty Officer. Normally, the CPO selected to fill this position will be given formal indoctrination and training at the NMCB homeport prior to the deployment.

Perhaps the foremost responsibility of the Safety Division is to constantly survey and inspect the battalion for unsafe practices and conditions. It is in this area that the Safety Officer utilizes the Safety Chief to best advantages, since it is the latter's responsibility to systematically visit and inspect every job site, shop, camp, and galley throughout the battalion. The Safety Chief's job is, however, much more than just being a safety monitor. He also acts as an advisor and consultant during his rounds, meeting informally with supervisors to answer questions and help develop and encourage safe practices. Both the Safety Officer and the Safety Chief have the authority, and duty, to stop any operation or practice that might cause injury to personnel or damage to material or equipment.

The Safety Division, under the Safety Officer, is also responsible for receiving and reviewing all accident reports and for preparing summaries and analyses of these reports. The Safety Officer also reviews the supervisor's proposals for corrective action and recommends acceptance of these proposals when appropriate.

Another important function of the Safety Division is the implementation of a safety training program throughout the battalion. It might be emphasized, in this connection, that the Safety Division (Safety Officer) will be your primary source of safety information and guidance. This information and guidance will be disseminated to you through your Project Safety Supervisor—who we will discuss in a moment. The Safety Officer, frequently with the assistance of the Educational Services Officer, provides for safety lectures, instructions, demonstrations, and many other activities centered on safety, such as safety movies, safety awards ceremonies, and placement of safety posters. As part of this safety training program, the Safety Officer is also responsible for organizing and coordinating the crew-level safety briefings, called Stand-Up Safety Meetings, which are conducted by the crew supervisor or Crew Petty Officer. More will be said about these meetings shortly.

A third safety group established in every NMCB, and the one with which you, as a petty officer and supervisor, will perhaps have the most direct contact, is the SUPERVISOR'S SAFETY COMMITTEE. This committee is composed of all the Project Safety Supervisors in the battalion. It might be well to pause here and explain that prior to the development of a NMCB, the construction expected of the battalion is identified and organized into units of work called projects. Each project is given a number and assigned a Project Officer (often a Chief Petty Officer), who has overall responsibility for the safe and successful completion of the project. To assist him in maintaining the necessary safety programs in his project, the Project Officer selects a capable Petty Officer, First or Second Class, and assigns him the collateral duty of Project Safety Supervisor. The duties of the Project Safety Supervisor are rather considerable. If you should become a Crew Petty Officer, the Project Safety Supervisor will be your primary contact in practically all matters concerning safety. For the moment, however, we are interested in him as a member of the Supervisor's Safety Committee.

The purpose of this last committee is to act as a focal point for the exchange of safety information and policies between the various projects. Since crews from different projects often work in close proximity, the hazards peculiar to the work of one crew sometimes affect the other, and vice versa. The Supervisor's Safety Committee thus provides a convenient forum where one project can apprise the others of its work procedures and related safety precautions. The committee also forms a convenient avenue by which any crew, or any individual, can forward recommendations for improved safety methods to the Safety Policy Committee.

The Safety Division, the Safety Policy Committee, and the Supervisors' Safety Committee together make up the formal safety organization of a NMCB, that is, those groups whose duties and functions center solely on safety. As a petty officer, however, and particularly as a Crew Petty Officer supervising a job, you will be preoccupied with many other responsibilities besides safety. Nevertheless, the fact remains that the ultimate achievement of safety in the NMCB rests with you. In truth, the Safety Division, the Safety Policy Committee, and the Supervisor's Safety Committee all operate to support you as a supervisor.

SAFETY DUTIES OF A SUPERVISOR

Every petty officer is responsible for the safety of personnel placed in his charge. Basically, your safety duties as a supervisor will revolve around training your subordinates, correcting unsafe practices and conditions should they occur, and being prepared to execute certain procedures should one of your men be involved in an accident.

Safety Training

New methods and procedures used in performing construction operations, and working in new and different situations, all require the supervisor to keep himself and his men informed of the latest in construction safety. Moreover, you can never assume that men transferred to your crew from some other crew are appropriately and fully trained in safety matters. For these reasons, the safety education and training of subordinates is a continuing responsibility of every supervisor.

To keep his men informed, every Crew Petty Officer periodically holds short (approximately 5 to 15 minutes) safety meetings, called Standup Safety Meetings. Standup meeting should be held prior to starting the day's work. Although the Crew Petty Officer is responsible for the actual conduct of the meetings, much of the content of the briefing is organized and assembled by the Safety Division and disseminated to the Crew Petty Officer through his Project Safety Supervisor. At times the Safety Division may suggest that you hold a group discussion on specific accidents that are to be guarded against or that may have happened in the unit. Give plenty of thought to what you are going to say beforehand, make the discussion interesting, and encourage the men to participate. A group conclusion as to how specific accidents can be prevented should be reached.

On occasion, the purpose of the Standup Safety Meeting may be to discuss safety problems that may develop because of new work procedures. If a particular piece of new equipment is being introduced into the system, a safety meeting may be called so that you can demonstrate the safe starting procedure for the equipment, and then have the men practice that procedure.

In addition to the Standup Safety Meetings, the CREW Petty Officer is, of course, also concerned with the incidental, day-to-day instruction and training of his men on the job. It is beyond the scope of this text to go into a discussion of teaching or training methods (see chapter 7, Military Requirements for Petty Officer 3 & 2, NAVPERS 10056-C). However, a few words on the petty officer's approach to safety and safety training at the crew level might be appropriate. The job of achieving safety in your crew is, like most other supervisory functions, essentially a matter of leadership. In studying and seeking to understand the practical aspects of directing and managing men, many new petty officers fail to recognize the power of personal example in leading and teaching subordinates. You will soon discover, in this regard, that subordinates are very quick to detect any difference between what you say and what you do. You cannot reasonably expect your men to measure up to standards of safety conduct and awareness which you yourself do not constantly DEMONSTRATE. It is not enough to be knowledgeable in the various aspects of construction safety. As a supervisor, you must make your genuine concern for the importance of crew safety visible and known to your men at all times. Leadership by example may not be the only technique of leadership, but it is one of the most eminently practical and time-proven methods of management available to you.

Accident Reporting Procedures

A well planned and conscientiously executed crew safety program will prevent accidents. Nevertheless, you must be prepared to carry out certain procedures should a man in your charge be injured or otherwise involved in an accident. It might be mentioned that for the purpose of accident reporting, an accident is defined as "Any unplanned act or event which results in damage to property, material or equipment and/or cargo, or personnel injury or death when not the result of hostile action." For purposes of this discussion, an injury may be defined as "Any physical impairment which prevents a Navy military person from performing his regularly established duty or work for a period of 24 hours or more subsequent to 2400 hours on the day of the injury." If an injury is the type which requires first aid or medical attention and the man can be returned to duty within 24 hours, or can resume some light form of work within 24 hours, the formal investigation and reporting procedures ordinarily will not be necessary. This is not to say, however, that you need not investigate these kinds of accidents on your own initiative. Small or seemingly harmless incidents often repeat themselves with more serious results. If an improper practice or condition exists in your crew, you must obviously identify and correct it before a serious accident occurs.

Supposing one of your men is injured, the first priority of course is to arrange for prompt medical treatment. At the same time, you must also take steps to prevent additional injuries or damage by shutting off power, stopping equipment or machinery, posting guards, and so on. Next, see to it that the Project Officer is notified of the accident. If the accident occurs outside of working hours, then the Officer of the Day is notified. If the accident is one that causes any physical impairment which will prevent the man from performing his regularly established duty for a period of 24 hours or more subsequent to 2400 of the day of injury, then it may be your responsibility as Crew Petty Officer to investigate the circumstances and submit a written report. The form you will use to report the accident is Accidental Injury/Death Report, OPNAV Form 5100/1, which supersedes the Accident Report NAVEXOS Form 108. It is important to note that this reporting requirement is in effect at all times. However, if one of your crew members is injured during non-working hours, the Safety Chief is responsible for conducting the investigation and submitting the report.

Figures 2-6 and 2-7 show the front and back, respectively, of the Accidental Injury/Death Report, OPNAV Form 5100/1. A supply of these forms is made available to each Crew Petty Officer. The form must be filled out in triplicate and forwarded to the Safety Officer via your Project Officer within 24 hours of the accident.

An instruction sheet which accompanies OPNAV Form 5100/1 provides instructions for filling in various blocks on the form which are not self-explanatory. Figures 2-8 and 2-9 show the front and back, respectively, of this instruction sheet. Study the instruction sheet carefully and make sure you fill in all applicable items on the report properly and neatly. Remember that thorough investigations of accidents will help to identify and correct deficiencies, and reduce to a minimum injuries and deaths to personnel from accidental causes.

Accidental injuries or deaths under certain circumstances do not have to be reported on the Accidental Injury/Death Report, (OPNAV Form 5100/1). If you have any questions as to when this report is required, routing instructions, and so on, consult your Project Safety Supervisor for advice on what to do in the matter.

At times you may be called upon to assist in preparing an Accident Damage Report for Naval Property Ashore, OPNAV Form 5100/2. This report is required for all property damage accidents which require repair or replacement other than that resulting from normal wear/usage and in which the damage loss, replacement cost or repair cost, including labor, is $100.00 or more. It is recommended that "near" accidents also be reported because studies of these incidents and the mechanisms involved which averted damage/injury/loss of life will provide meaningful information which, in relation to other data, will enable more precise determination of preventive and corrective action required.

Figures 2-10 and 2-11 show the front and back, respectively, of the Accident Damage Report for Naval Property Ashore, OPNAV Form 5100/2.

The Commanding Officer or Officer-in-Charge of the command at which the accident damage occurs is responsible for coordinating the preparation and submission of the Accident Damage Report for Naval Property Ashore. The designated representative of the command will conduct investigations as required and complete the Accident Damage Report. After the form has been prepared, submission must be made to the Safety Officer via the Company Commander/Project Officer within 72 hours of the accident.

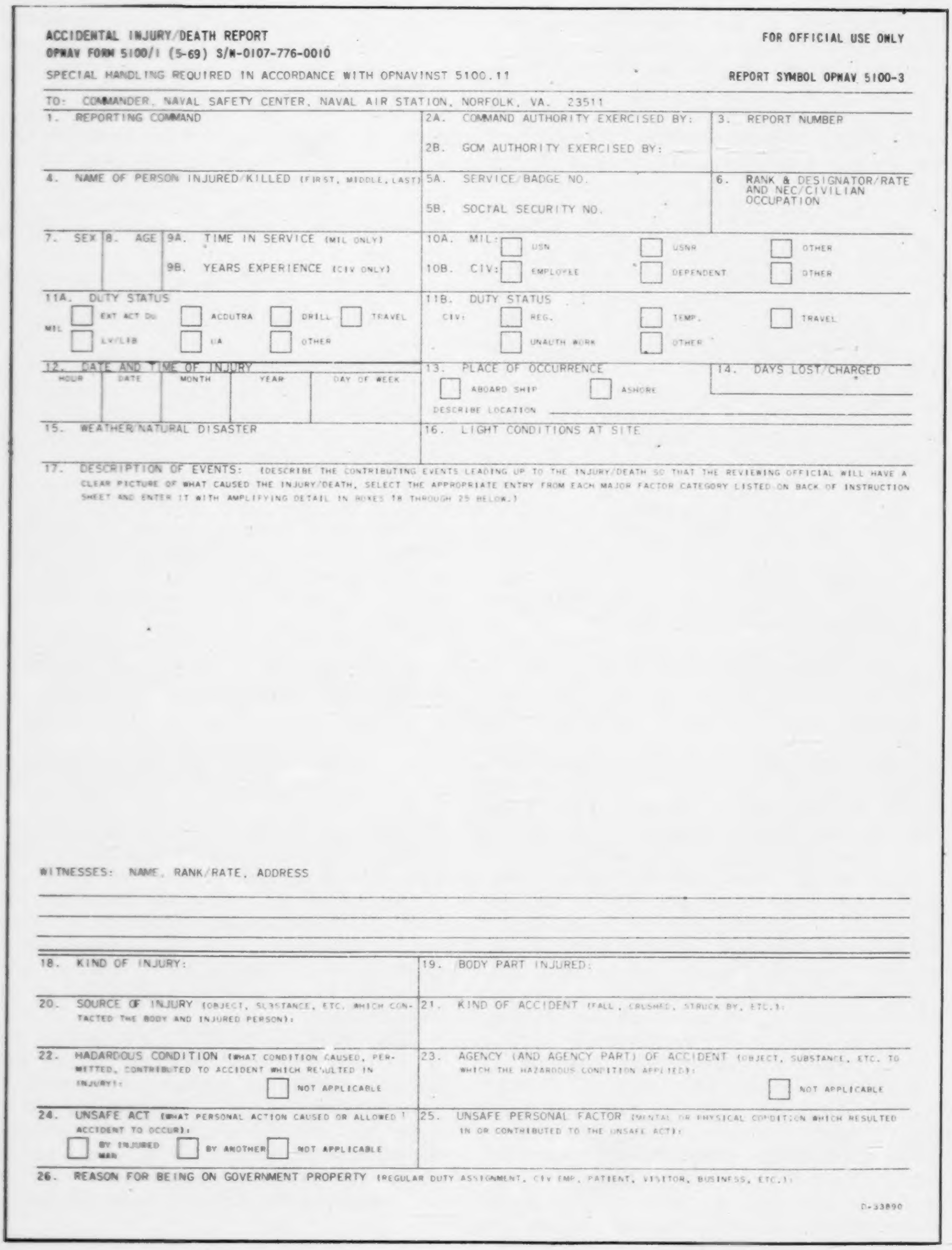
Consult with your project supervisor for advice on what to do if you are called upon to assist in the preparation of this report.

THE PERSONNEL READINESS CAPABILITY PROGRAM

The Personnel Readiness Capability Program (PRCP) provides a standard means of identifying, collecting, processing, and utilizing information on all members of the Naval Construction Force, both active and reserve. This information can be used by all levels of management and supervision to determine a unit's readiness capability by comparing it to actual or planned requirements.

The majority of PRCP information consists of an inventory of individual skills acquired through formal or on-the-job training. A record of these skills, combined with other data from the service record, such as expiration of enlistment, rotation data, etc., provides a ready means of predicting future capabilities and requirements. Some of these may be:

a. Construction and military capabilities.
b. Personnel, logistics, and training requirements.



ACCIDENTAL INJURY/DEATH REPORT
OPNAV FORM 5100/1 (5-69) S/N-0107-776-0010
SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 5100.11

FOR OFFICIAL USE ONLY
REPORT SYMBOL OPNAV 5100-3

TO: COMMANDER, NAVAL SAFETY CENTER, NAVAL AIR STATION, NORFOLK, VA. 23511

1. REPORTING COMMAND
2A. COMMAND AUTHORITY EXERCISED BY:
2B. GCM AUTHORITY EXERCISED BY:
3. REPORT NUMBER
4. NAME OF PERSON INJURED/KILLED (FIRST, MIDDLE, LAST)
5A. SERVICE/BADGE NO.
5B. SOCIAL SECURITY NO.
6. RANK & DESIGNATOR/RATE AND NEC/CIVILIAN OCCUPATION
7. SEX
8. AGE
9A. TIME IN SERVICE (MIL ONLY)
9B. YEARS EXPERIENCE (CIV ONLY)
10A. MIL: ☐ USN ☐ USNR ☐ OTHER
10B. CIV: ☐ EMPLOYEE ☐ DEPENDENT ☐ OTHER
11A. DUTY STATUS
MIL ☐ EXT ACT DU ☐ ACDUTRA ☐ DRILL ☐ TRAVEL
☐ LV/LIB ☐ UA ☐ OTHER
11B. DUTY STATUS
CIV: ☐ REG. ☐ TEMP. ☐ TRAVEL
☐ UNAUTH WORK ☐ OTHER
12. DATE AND TIME OF INJURY

HOUR	DATE	MONTH	YEAR	DAY OF WEEK

13. PLACE OF OCCURRENCE
☐ ABOARD SHIP ☐ ASHORE
DESCRIBE LOCATION
14. DAYS LOST/CHARGED
15. WEATHER/NATURAL DISASTER
16. LIGHT CONDITIONS AT SITE
17. DESCRIPTION OF EVENTS: (DESCRIBE THE CONTRIBUTING EVENTS LEADING UP TO THE INJURY/DEATH SO THAT THE REVIEWING OFFICIAL WILL HAVE A CLEAR PICTURE OF WHAT CAUSED THE INJURY/DEATH, SELECT THE APPROPRIATE ENTRY FROM EACH MAJOR FACTOR CATEGORY LISTED ON BACK OF INSTRUCTION SHEET AND ENTER IT WITH AMPLIFYING DETAIL IN BOXES 18 THROUGH 25 BELOW.)

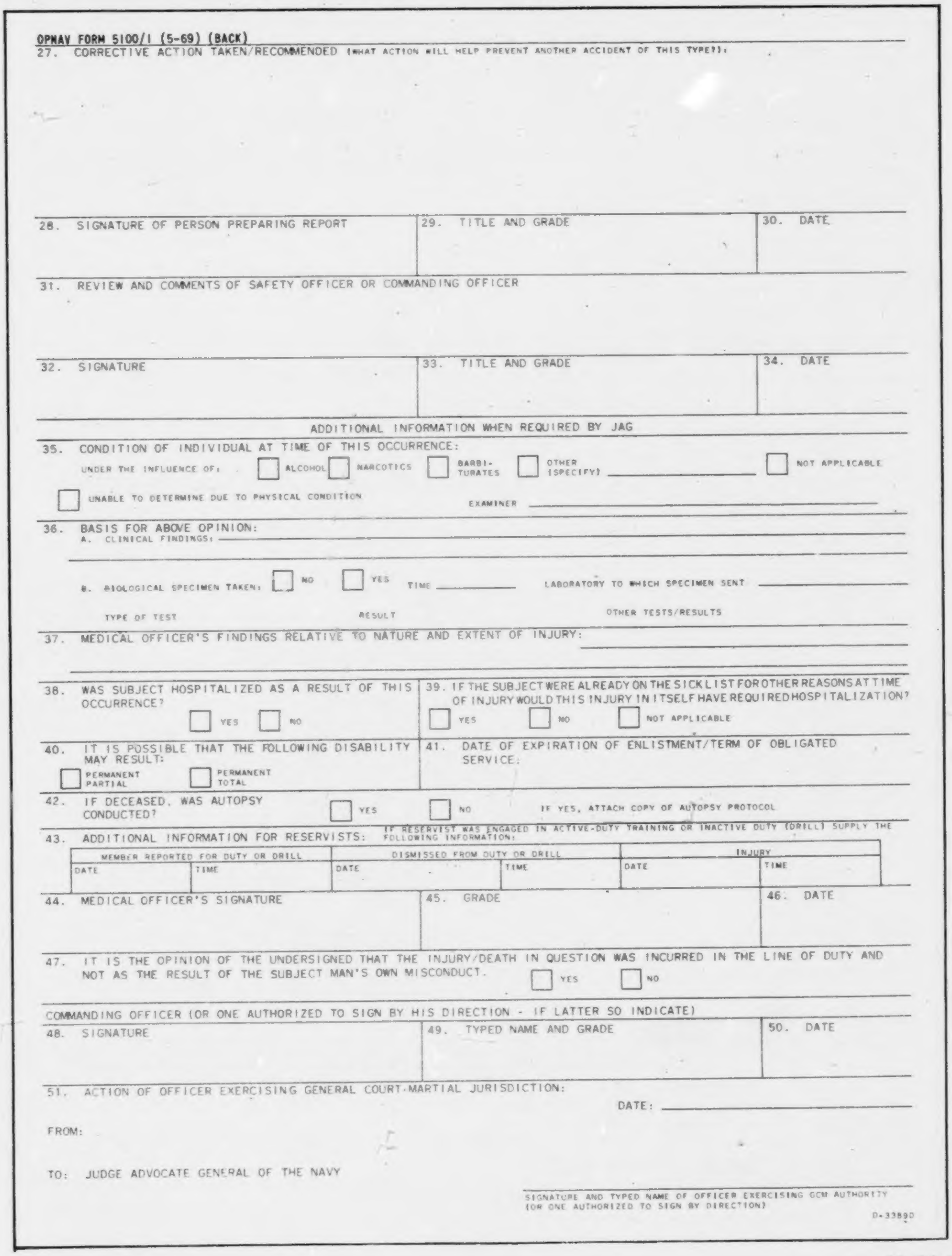
WITNESSES: NAME, RANK/RATE, ADDRESS

18. KIND OF INJURY:
19. BODY PART INJURED:
20. SOURCE OF INJURY (OBJECT, SUBSTANCE, ETC. WHICH CONTACTED THE BODY AND INJURED PERSON):
21. KIND OF ACCIDENT (FALL, CRUSHED, STRUCK BY, ETC.):
22. HADARDOUS CONDITION (WHAT CONDITION CAUSED, PERMITTED, CONTRIBUTED TO ACCIDENT WHICH RESULTED IN INJURY): ☐ NOT APPLICABLE
23. AGENCY (AND AGENCY PART) OF ACCIDENT (OBJECT, SUBSTANCE, ETC. TO WHICH THE HAZARDOUS CONDITION APPLIED): ☐ NOT APPLICABLE
24. UNSAFE ACT (WHAT PERSONAL ACTION CAUSED OR ALLOWED ACCIDENT TO OCCUR): ☐ BY INJURED MAN ☐ BY ANOTHER ☐ NOT APPLICABLE
25. UNSAFE PERSONAL FACTOR (MENTAL OR PHYSICAL CONDITION WHICH RESULTED IN OR CONTRIBUTED TO THE UNSAFE ACT):
26. REASON FOR BEING ON GOVERNMENT PROPERTY (REGULAR DUTY ASSIGNMENT, CIV EMP, PATIENT, VISITOR, BUSINESS, ETC.):

D-33890

29.52.1(2D)

Figure 2-6.—Accidental injury/death report, OPNAV Form 5100/1 (front).



OPNAV FORM 5100/1 (5-69) (BACK)

27. CORRECTIVE ACTION TAKEN/RECOMMENDED (WHAT ACTION WILL HELP PREVENT ANOTHER ACCIDENT OF THIS TYPE?):

28. SIGNATURE OF PERSON PREPARING REPORT	29. TITLE AND GRADE	30. DATE

31. REVIEW AND COMMENTS OF SAFETY OFFICER OR COMMANDING OFFICER

32. SIGNATURE	33. TITLE AND GRADE	34. DATE

ADDITIONAL INFORMATION WHEN REQUIRED BY JAG

35. CONDITION OF INDIVIDUAL AT TIME OF THIS OCCURRENCE:
UNDER THE INFLUENCE OF: ☐ ALCOHOL ☐ NARCOTICS ☐ BARBITURATES ☐ OTHER (SPECIFY) ________ ☐ NOT APPLICABLE
☐ UNABLE TO DETERMINE DUE TO PHYSICAL CONDITION EXAMINER ________

36. BASIS FOR ABOVE OPINION:
A. CLINICAL FINDINGS: ________
B. BIOLOGICAL SPECIMEN TAKEN: ☐ NO ☐ YES TIME ________ LABORATORY TO WHICH SPECIMEN SENT ________
TYPE OF TEST RESULT OTHER TESTS/RESULTS

37. MEDICAL OFFICER'S FINDINGS RELATIVE TO NATURE AND EXTENT OF INJURY: ________

38. WAS SUBJECT HOSPITALIZED AS A RESULT OF THIS OCCURRENCE? ☐ YES ☐ NO	39. IF THE SUBJECT WERE ALREADY ON THE SICK LIST FOR OTHER REASONS AT TIME OF INJURY WOULD THIS INJURY IN ITSELF HAVE REQUIRED HOSPITALIZATION? ☐ YES ☐ NO ☐ NOT APPLICABLE
40. IT IS POSSIBLE THAT THE FOLLOWING DISABILITY MAY RESULT: ☐ PERMANENT PARTIAL ☐ PERMANENT TOTAL	41. DATE OF EXPIRATION OF ENLISTMENT/TERM OF OBLIGATED SERVICE:

42. IF DECEASED, WAS AUTOPSY CONDUCTED? ☐ YES ☐ NO IF YES, ATTACH COPY OF AUTOPSY PROTOCOL

43. ADDITIONAL INFORMATION FOR RESERVISTS: IF RESERVIST WAS ENGAGED IN ACTIVE-DUTY TRAINING OR INACTIVE DUTY (DRILL) SUPPLY THE FOLLOWING INFORMATION:

MEMBER REPORTED FOR DUTY OR DRILL		DISMISSED FROM DUTY OR DRILL		INJURY	
DATE	TIME	DATE	TIME	DATE	TIME

44. MEDICAL OFFICER'S SIGNATURE	45. GRADE	46. DATE

47. IT IS THE OPINION OF THE UNDERSIGNED THAT THE INJURY/DEATH IN QUESTION WAS INCURRED IN THE LINE OF DUTY AND NOT AS THE RESULT OF THE SUBJECT MAN'S OWN MISCONDUCT. ☐ YES ☐ NO

COMMANDING OFFICER (OR ONE AUTHORIZED TO SIGN BY HIS DIRECTION - IF LATTER SO INDICATE)

48. SIGNATURE	49. TYPED NAME AND GRADE	50. DATE

51. ACTION OF OFFICER EXERCISING GENERAL COURT-MARTIAL JURISDICTION:
DATE: ________

FROM:

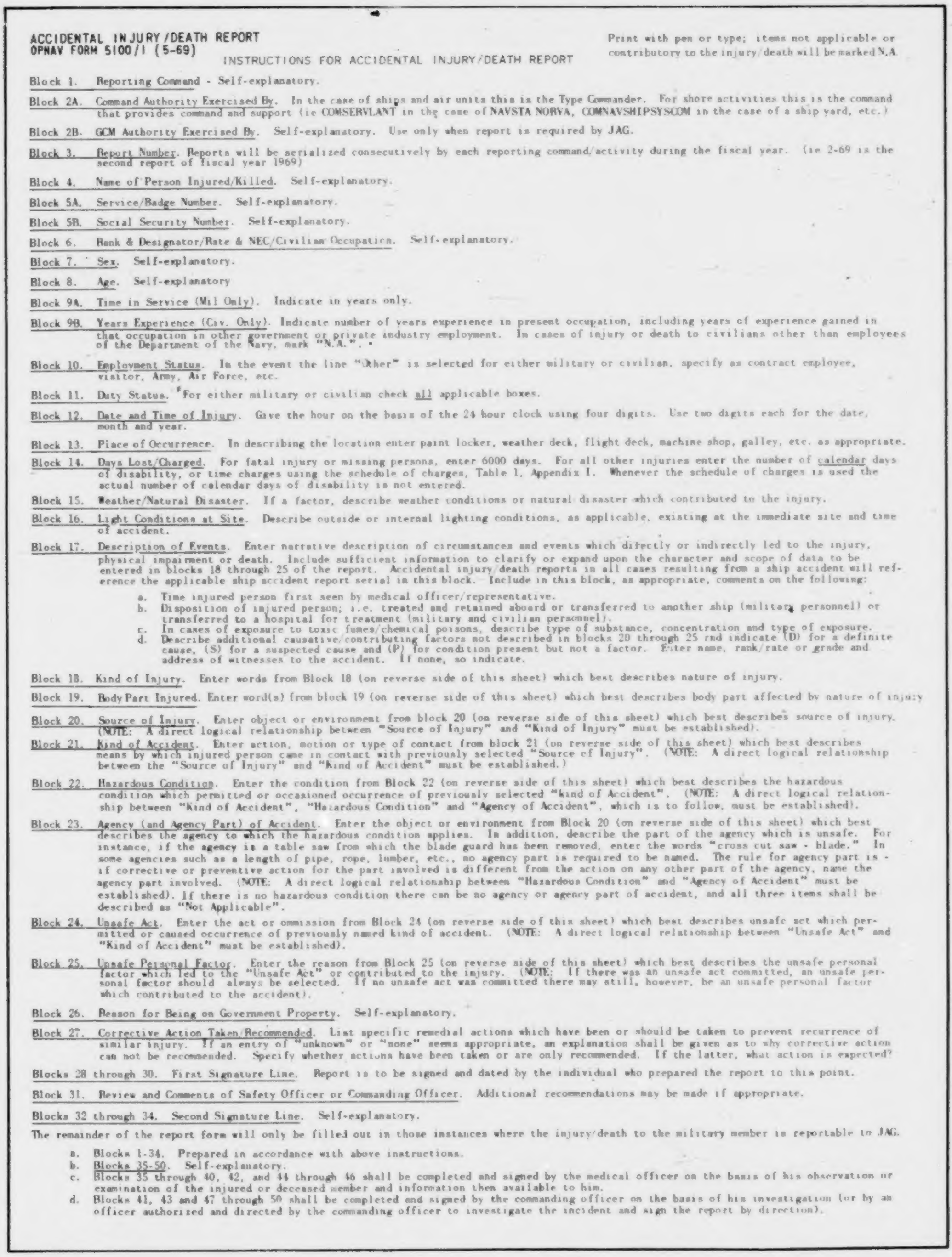
TO: JUDGE ADVOCATE GENERAL OF THE NAVY

SIGNATURE AND TYPED NAME OF OFFICER EXERCISING GCM AUTHORITY
(OR ONE AUTHORIZED TO SIGN BY DIRECTION)

D-33890

29.52.2(2D)

Figure 2-7.—Accidental injury/death report, OPNAV Form 5100/1 (back).



ACCIDENTAL INJURY/DEATH REPORT
OPNAV FORM 5100/1 (5-69)

INSTRUCTIONS FOR ACCIDENTAL INJURY/DEATH REPORT

Print with pen or type; items not applicable or contributory to the injury/death will be marked N.A

Block 1. Reporting Command - Self-explanatory.

Block 2A. Command Authority Exercised By. In the case of ships and air units this is the Type Commander. For shore activities this is the command that provides command and support (ie COMSERVLANT in the case of NAVSTA NORVA, COMNAVSHIPSYSCOM in the case of a ship yard, etc.)

Block 2B. GCM Authority Exercised By. Self-explanatory. Use only when report is required by JAG.

Block 3. Report Number. Reports will be serialized consecutively by each reporting command/activity during the fiscal year. (ie 2-69 is the second report of fiscal year 1969)

Block 4. Name of Person Injured/Killed. Self-explanatory.

Block 5A. Service/Badge Number. Self-explanatory.

Block 5B. Social Security Number. Self-explanatory.

Block 6. Rank & Designator/Rate & NEC/Civilian Occupation. Self-explanatory.

Block 7. Sex. Self-explanatory.

Block 8. Age. Self-explanatory

Block 9A. Time in Service (Mil Only). Indicate in years only.

Block 9B. Years Experience (Civ. Only). Indicate number of years experience in present occupation, including years of experience gained in that occupation in other government or private industry employment. In cases of injury or death to civilians other than employees of the Department of the Navy, mark "N.A.". *

Block 10. Employment Status. In the event the line "Other" is selected for either military or civilian, specify as contract employee, visitor, Army, Air Force, etc.

Block 11. Duty Status. *For either military or civilian check all applicable boxes.

Block 12. Date and Time of Injury. Give the hour on the basis of the 24 hour clock using four digits. Use two digits each for the date, month and year.

Block 13. Place of Occurrence. In describing the location enter paint locker, weather deck, flight deck, machine shop, galley, etc. as appropriate.

Block 14. Days Lost/Charged. For fatal injury or missing persons, enter 6000 days. For all other injuries enter the number of calendar days of disability, or time charges using the schedule of charges, Table 1, Appendix I. Whenever the schedule of charges is used the actual number of calendar days of disability is not entered.

Block 15. Weather/Natural Disaster. If a factor, describe weather conditions or natural disaster which contributed to the injury.

Block 16. Light Conditions at Site. Describe outside or internal lighting conditions, as applicable, existing at the immediate site and time of accident.

Block 17. Description of Events. Enter narrative description of circumstances and events which directly or indirectly led to the injury, physical impairment or death. Include sufficient information to clarify or expand upon the character and scope of data to be entered in blocks 18 through 25 of the report. Accidental injury/death reports in all cases resulting from a ship accident will reference the applicable ship accident report serial in this block. Include in this block, as appropriate, comments on the following:

a. Time injured person first seen by medical officer/representative.
b. Disposition of injured person; i.e. treated and retained aboard or transferred to another ship (military personnel) or transferred to a hospital for treatment (military and civilian personnel).
c. In cases of exposure to toxic fumes/chemical poisons, describe type of substance, concentration and type of exposure.
d. Describe additional causative/contributing factors not described in blocks 20 through 25 rnd indicate (D) for a definite cause, (S) for a suspected cause and (P) for condition present but not a factor. Enter name, rank/rate or grade and address of witnesses to the accident. If none, so indicate.

Block 18. Kind of Injury. Enter words from Block 18 (on reverse side of this sheet) which best describes nature of injury.

Block 19. Body Part Injured. Enter word(s) from block 19 (on reverse side of this sheet) which best describes body part affected by nature of injury

Block 20. Source of Injury. Enter object or environment from block 20 (on reverse side of this sheet) which best describes source of injury. (NOTE: A direct logical relationship between "Source of Injury" and "Kind of Injury" must be established).

Block 21. Kind of Accident. Enter action, motion or type of contact from block 21 (on reverse side of this sheet) which best describes means by which injured person came in contact with previously selected "Source of Injury". (NOTE: A direct logical relationship between the "Source of Injury" and "Kind of Accident" must be established.)

Block 22. Hazardous Condition. Enter the condition from Block 22 (on reverse side of this sheet) which best describes the hazardous condition which permitted or occasioned occurrence of previously selected "kind of Accident". (NOTE: A direct logical relationship between "Kind of Accident", "Hazardous Condition" and "Agency of Accident", which is to follow, must be established).

Block 23. Agency (and Agency Part) of Accident. Enter the object or environment from Block 20 (on reverse side of this sheet) which best describes the agency to which the hazardous condition applies. In addition, describe the part of the agency which is unsafe. For instance, if the agency is a table saw from which the blade guard has been removed, enter the words "cross cut saw - blade." In some agencies such as a length of pipe, rope, lumber, etc., no agency part is required to be named. The rule for agency part is - if corrective or preventive action for the part involved is different from the action on any other part of the agency, name the agency part involved. (NOTE: A direct logical relationship between "Hazardous Condition" and "Agency of Accident" must be established). If there is no hazardous condition there can be no agency or agency part of accident, and all three items shall be described as "Not Applicable".

Block 24. Unsafe Act. Enter the act or ommission from Block 24 (on reverse side of this sheet) which best describes unsafe act which permitted or caused occurrence of previously named kind of accident. (NOTE: A direct logical relationship between "Unsafe Act" and "Kind of Accident" must be established).

Block 25. Unsafe Personal Factor. Enter the reason from Block 25 (on reverse side of this sheet) which best describes the unsafe personal factor which led to the "Unsafe Act" or contributed to the injury. (NOTE: If there was an unsafe act committed, an unsafe personal factor should always be selected. If no unsafe act was committed there may still, however, be an unsafe personal factor which contributed to the accident).

Block 26. Reason for Being on Government Property. Self-explanatory.

Block 27. Corrective Action Taken/Recommended. List specific remedial actions which have been or should be taken to prevent recurrence of similar injury. If an entry of "unknown" or "none" seems appropriate, an explanation shall be given as to why corrective action can not be recommended. Specify whether actions have been taken or are only recommended. If the latter, what action is expected?

Blocks 28 through 30. First Signature Line. Report is to be signed and dated by the individual who prepared the report to this point.

Block 31. Review and Comments of Safety Officer or Commanding Officer. Additional recommendations may be made if appropriate.

Blocks 32 through 34. Second Signature Line. Self-explanatory.

The remainder of the report form will only be filled out in those instances where the injury/death to the military member is reportable to JAG.

a. Blocks 1-34. Prepared in accordance with above instructions.
b. Blocks 35-50. Self-explanatory.
c. Blocks 35 through 40, 42, and 44 through 46 shall be completed and signed by the medical officer on the basis of his observation or examination of the injured or deceased member and information then available to him.
d. Blocks 41, 43 and 47 through 50 shall be completed and signed by the commanding officer on the basis of his investigation (or by an officer authorized and directed by the commanding officer to investigate the incident and sign the report by direction).

29.52.3(127E)

Figure 2-8.—Instructions for accidental injury/death report (front).

BLOCK 18. KIND OF INJURY

AMPUTATION OR ENUCLEATION
ASPHYXIA, STRANGULATION
BURN OR SCALD (THERMAL)
BURN (CHEMICAL)
CAISSON DISEASE, BENDS
CONCUSSION, BRAIN
CONTUSION, CRUSHING, BRUISE
CUT, LACERATION, PUNCTURE, OPEN WOUND
DISLOCATION
DROWNING
ELECTRIC SHOCK, ELECTROCUTION
FOREIGN BODY LOOSE (DUST, RUST, SOOT)
FOREIGN BODY, RETAINED OR EMBEDDED
FRACTURE
FREEZING, FROSTBITE
HEARING LOSS, OR IMPAIRMENT
HEAT STROKE, SUNSTROKE, HEAT EXHAUSTION
HERNIA
•INJURIES, INTERNAL
•POISONING, SYSTEMIC
RADIATION, IONIZING
RADIATION, NONIONIZING
RADIATION, ACTINIC
SCRATCHES, ABRASIONS
SPRAINS, STRAINS
SUBMERSION, NONFATAL
•MULTIPLE INJURIES
UNDETERMINED
•OCCUPATIONAL DISEASE, NEC
•OTHER INJURY, NEC

BLOCK 19. BODY PART INJURED

•HEAD (INCLUDING FACE)
•NECK
•UPPER EXTREMITIES
•TRUNK
•LOWER EXTREMITIES
•MULTIPLE PARTS
•BODY SYSTEM
•BODY PARTS, NEC

BLOCKS 20 & 23. SOURCE OF INJURY AND AGENCY OF ACCIDENT

•AIR PRESSURE
•ANIMALS
•BODILY MOTION
•BOILERS, PRESSURE VESSELS - PARTS
•BOXES, BARRELS, CONTAINERS, PACKAGES (EMPTY OR FULL, EXCEPT GLASS)
•BUILDINGS & STRUCTURES - PARTS
•CHEMICALS & CHEMICAL COMPOUNDS
•CLOTHING, APPAREL, SHOES
•COAL AND PETROLEUM PRODUCTS
•CONSTRUCTION MATERIALS (NOT PART OF A STRUCTURE)
•CONVEYORS, GRAVITY OR POWERED (EXCEPT PLANT & INDUSTRIAL VEHICLES)
•DRUGS AND MEDICINES
•ELECTRIC & ELECTRONIC APPARATUS, NEC
•FLAME, FIRE, SMOKE
•FOREIGN BODIES OR UNIDENTIFIED ARTICLES
•FURNITURE, FIXTURES, FURNISHINGS
•GLASS & CERAMIC ITEMS, NEC
•HAND TOOLS (NOT POWERED; WHEN IN USE, CARRIED BY A PERSON)
•HAND TOOLS (MECH. & ELEC. MOTOR POWERED; IN USE, CARRIED AND HELD BY A PERSON)
•HEATING EQUIPMENT, NEC (NOT ELEC.) WHEN IN USE (FOR ELEC. FURNACES SEE ELECTRONIC APPARATUS)
•HOISTING APPARATUS
•ELEVATORS
•HUMAN BEING
•INSTRUMENTALITIES OF WAR
•MACHINES (PORTABLE & FIXED, EXCEPT WHEELED VEHICLES)
•METAL ITEMS, NEC
•MINERAL ITEMS, NEC
•NATURAL POISONS AND TOXIC AGENTS, NEC
NOISE
•PERSONNEL SUPPORTING SURFACES (DECK, LADDER, STAGE, BROW, PLATFORM)
•PLASTIC ITEMS, NEC
•PUMPS, ENGINES, TURBINES (NOT ELEC.)
•RADIATING SUBSTANCES AND EQUIPMENT (USE ONLY FOR RADIATION INJURIES)
•SCRAP, DEBRIS, WASTE MATERIAL, ETC., NEC (EXCEPT RADIOACTIVE)
•SHIP STRUCTURE - PARTS
•SPORTS
•TEMPERATURE (ATMOSPHERIC, ENVIRONMENTAL)
•TEXTILE ITEMS, NEC
•VEHICLES, (AIR, LAND, SEA) INCLUDING MILITARY AND INDUSTRIAL
WATER AND STEAM
•WOOD ITEMS, NEC
•MISCELLANEOUS, NEC
UNDETERMINED
•OTHER, NEC

BLOCK 21. KIND OF ACCIDENT

•STRUCK AGAINST
•STRUCK BY
•FALL OR JUMP FROM ELEVATION
•FALL OR JUMP ON SAME LEVEL
•CAUGHT IN, UNDER, OR BETWEEN
BITE OR STING, VENOMOUS AND NON-VENOMOUS
•RUBBED, ABRADED, PUNCTURED OR CUT
BODILY REACTION OR MOTION
•OVEREXERTION
•CONTACT WITH
UNDETERMINED
•OTHER, NEC

BLOCK 22. HAZARDOUS CONDITION

•DEFECT OF THE AGENCY OF ACCIDENT
•DRESS OR APPAREL HAZARD
•IMPROPER ILLUMINATION
•IMPROPER VENTILATION
•ENVIRONMENTAL HAZARD, NEC
•HAZARD OF OUTSIDE WORK ENVIRONMENT – OTHER
•INADEQUATELY GUARDED
•PLACEMENT HAZARD
•PUBLIC HAZARD
UNDETERMINED
NO HAZARDOUS CONDITION
•HAZARDOUS CONDITION, NEC

BLOCK 24. UNSAFE ACT

•WORKING ON MOVING OR DANGEROUS EQUIPMENT
•DRIVING ERRORS BY VEHICLE OPERATOR
•FAILURE TO USE PERSONAL PROTECTIVE EQUIPMENT
FAILURE TO WEAR SAFE PERSONAL ATTIRE
•FAILURE TO SECURE OR WARN
HORSEPLAY AND SKYLARKING
QUARRELING OR FIGHTING
•IMPROPER USE OF EQUIPMENT
•IMPROPER USE OF HANDS OR BODY PARTS
INATTENTION TO FOOTING OR SURROUNDINGS
•FAILURE TO USE SAFETY DEVICES
•OPERATING OR WORKING AT UNSAFE SPEED
•TAKING UNSAFE POSITION OR POSTURE
•UNSAFE PLACING, MIXING, COMBINING, ETC.
•USING UNSAFE EQUIPMENT
•OTHER UNSAFE ACTS, NEC
UNDETERMINED
NO UNSAFE ACT
NEC - NOT ELSEWHERE CLASSIFIED

BLOCK 25. UNSAFE PERSONAL FACTOR

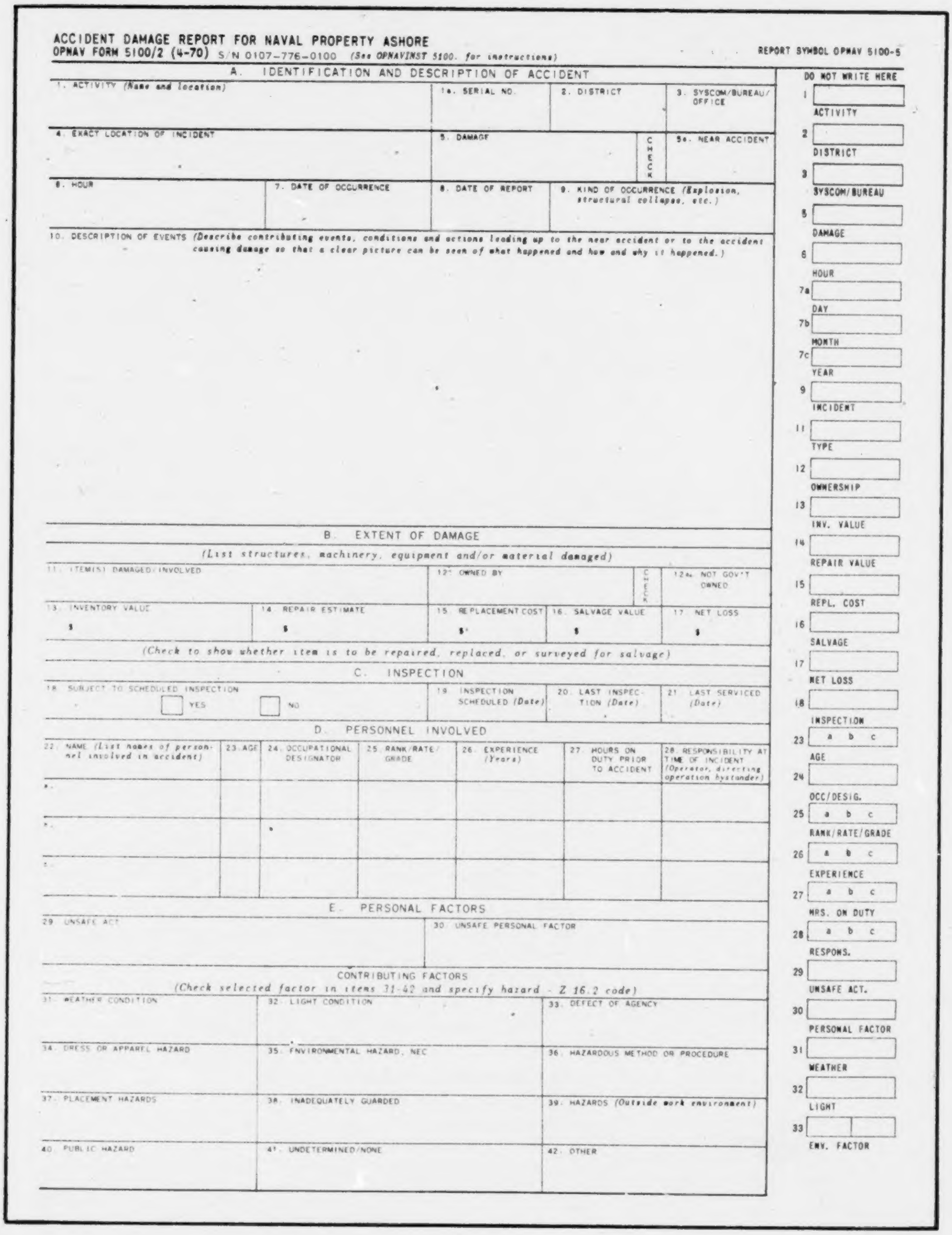
UNDER INFLUENCE DRUG/ALCOHOL
FATIGUE
ILLNESS
•IMPROPER ATTITUDE
•LACK OF KNOWLEDGE OR SKILL
•BODILY DEFECTS
UNDETERMINED
NO UNSAFE PERSONAL FACTOR
•OTHER UNSAFE PERSONAL FACTOR, NEC

•SPECIFY/DETAIL

U-33890

29.52.4(127E)

Figure 2-9.—Instructions for accidental injury/death report (back).



ACCIDENT DAMAGE REPORT FOR NAVAL PROPERTY ASHORE
OPNAV FORM 5100/2 (4-70) S/N 0107-776-0100 *(See OPNAVINST 5100. for instructions)*

REPORT SYMBOL OPNAV 5100-5

A. IDENTIFICATION AND DESCRIPTION OF ACCIDENT

1. ACTIVITY *(Name and location)*	1a. SERIAL NO.	2. DISTRICT	3. SYSCOM/BUREAU/ OFFICE
4. EXACT LOCATION OF INCIDENT	5. DAMAGE	CHECK	5a. NEAR ACCIDENT
6. HOUR	7. DATE OF OCCURRENCE	8. DATE OF REPORT	9. KIND OF OCCURRENCE *(Explosion, structural collapse, etc.)*

10. DESCRIPTION OF EVENTS *(Describe contributing events, conditions and actions leading up to the near accident or to the accident causing damage so that a clear picture can be seen of what happened and how and why it happened.)*

B. EXTENT OF DAMAGE

(List structures, machinery, equipment and/or material damaged)

11. ITEM(S) DAMAGED/INVOLVED		12. OWNED BY	CHECK	12a. NOT GOV'T OWNED
13. INVENTORY VALUE $	14. REPAIR ESTIMATE $	15. REPLACEMENT COST $	16. SALVAGE VALUE $	17. NET LOSS $

(Check to show whether item is to be repaired, replaced, or surveyed for salvage)

C. INSPECTION

18. SUBJECT TO SCHEDULED INSPECTION ☐ YES ☐ NO	19. INSPECTION SCHEDULED *(Date)*	20. LAST INSPECTION *(Date)*	21. LAST SERVICED *(Date)*

D. PERSONNEL INVOLVED

22. NAME *(List names of personnel involved in accident)*	23. AGE	24. OCCUPATIONAL DESIGNATOR	25. RANK/RATE/GRADE	26. EXPERIENCE *(Years)*	27. HOURS ON DUTY PRIOR TO ACCIDENT	28. RESPONSIBILITY AT TIME OF INCIDENT *(Operator, directing operation bystander)*
a.						
b.						
c.						

E. PERSONAL FACTORS

29. UNSAFE ACT	30. UNSAFE PERSONAL FACTOR

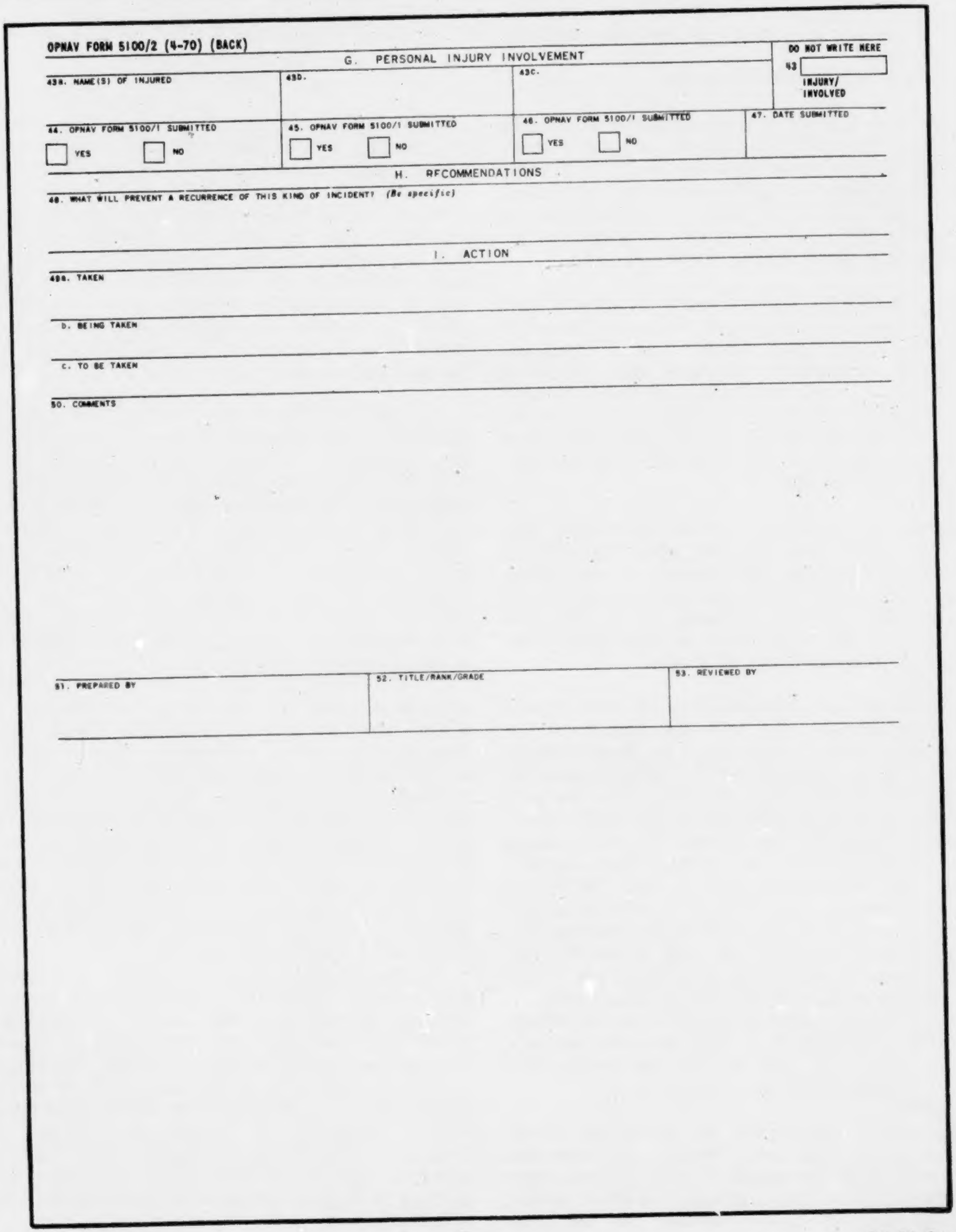
CONTRIBUTING FACTORS
(Check selected factor in items 31-42 and specify hazard - Z 16.2 code)

31. WEATHER CONDITION	32. LIGHT CONDITION	33. DEFECT OF AGENCY
34. DRESS OR APPAREL HAZARD	35. ENVIRONMENTAL HAZARD, NEC	36. HAZARDOUS METHOD OR PROCEDURE
37. PLACEMENT HAZARDS	38. INADEQUATELY GUARDED	39. HAZARDS *(Outside work environment)*
40. PUBLIC HAZARD	41. UNDETERMINED/NONE	42. OTHER

DO NOT WRITE HERE

1 ☐ ACTIVITY
2 ☐ DISTRICT
3 ☐ SYSCOM/BUREAU
5 ☐ DAMAGE
6 ☐ HOUR
7a ☐ DAY
7b ☐ MONTH
7c ☐ YEAR
9 ☐ INCIDENT
11 ☐ TYPE
12 ☐ OWNERSHIP
13 ☐ INV. VALUE
14 ☐ REPAIR VALUE
15 ☐ REPL. COST
16 ☐ SALVAGE
17 ☐ NET LOSS
18 ☐ INSPECTION
23 a b c AGE
24 ☐ OCC/DESIG.
25 a b c RANK/RATE/GRADE
26 a b c EXPERIENCE
27 a b c HRS. ON DUTY
28 a b c RESPONS.
29 ☐ UNSAFE ACT.
30 ☐ PERSONAL FACTOR
31 ☐ WEATHER
32 ☐ LIGHT
33 ☐ ☐ ENV. FACTOR

29.52.1(115G)
Figure 2-10.—Accident damage report for Naval property ashore, OPNAV Form 5100/2 (front).



OPNAV FORM 5100/2 (4-70) (BACK)

G. PERSONAL INJURY INVOLVEMENT

43a. NAME(S) OF INJURED	43b.	43c.	DO NOT WRITE HERE 43 ☐ INJURY/ INVOLVED
44. OPNAV FORM 5100/1 SUBMITTED ☐ YES ☐ NO	45. OPNAV FORM 5100/1 SUBMITTED ☐ YES ☐ NO	46. OPNAV FORM 5100/1 SUBMITTED ☐ YES ☐ NO	47. DATE SUBMITTED

H. RECOMMENDATIONS

48. WHAT WILL PREVENT A RECURRENCE OF THIS KIND OF INCIDENT? *(Be specific)*

I. ACTION

49a. TAKEN

b. BEING TAKEN

c. TO BE TAKEN

50. COMMENTS

51. PREPARED BY	52. TITLE/RANK/GRADE	53. REVIEWED BY

29.52.2(115G)

Figure 2-11.—Accident damage report for Naval property ashore, OPNAV Form 5100/2 (back).

c. Berthing, messing, and housing requirements.
d. Contingency requirements.

The most important aspects of the Personnel Readiness Capability Program, at your level, are collecting and passing along skill information on yourself and your men. However, the initial PRCP skill inventory will be based upon an interview with your crew/squard leader or another senior petty officer of your rating.

Special PRCP Interviewer's Standards and Guides have been prepared to assist persons conducting interviews. Each "Guide" contains a detailed explanation of every skill identified in the PRCP. These definitions are now standard throughout the entire Naval Construction Force, and any man, regardless of duty assignment, can turn to these standards and know what is expected in a given skill area.

During an interview, it is imperative that you and your men discuss your capabilities openly and honestly. Remember, if you exaggerate, you may be depriving yourselves of valuable and needed training. Then too, you may be the one selected to do that special job all on your own. Will you be ready?

It will be the responsibility of your supervisors to provide you with the opportunity to learn new skills. This may be done through training or by assigning your team to various types of work whenever possible. You can help by learning what is required in the PRCP Interviewer's Standards and Guides for your rating; then, as you and your men satisfy those requirements, you can report this to your PRCP coordinator; and, he will have the information added to your inventory of capabilities. By keeping your PRCP record current, you can avoid the unpleasantness of attending training in areas you are already proficient in. Like practical factors, it is primarily your responsibility for seeing that this information is kept current and accurate. After all, you will be the first to feel that you are qualified in a new skill.

All PRCP information is ultimately stored in a computer data bank. People who work with computers have developed a very realistic saying: "Garbage in: Garbage out." In other words, the accuracy of reports devised for the Personnel Readiness Capability Program will only be as accurate as the information you provide.

NAVY ENLISTED CLASSIFICATION CODES (NECs) AND "C" SCHOOLS

The Equipment Operator rating is a source of a number of NEC (Navy Enlisted Classification) codes. NECs reflect special knowledge and skills in certain ratings. The NEC Coding system is designed to facilitate management control over enlisted skills by accurately identifying billets and personnel. It also helps ensure maximum skill utilization in distribution and detailing. The following NECs may be earned by Equipment Operators at certain grade levels who satisfactorily complete an applicable course of instruction at a Navy Class "C" school:

1. WATER WELL DRILLING TECHNICIAN (EO-5707) — He sets up and operates well drilling machines to drill water wells. In doing this, he hoists tubular casing and bolts necessary connections; manipulates levers to control drill and drive casing; threads additional casings and drives casing into well as hole deepens; removes samples of subterrain and supervises crewmen of other ratings as required. This NEC is assigned only to personnel in paygrades E-5 through E-7 upon satisfactory completion of the applicable course.
2. BLASTER (EO-5708) — He places and detonates explosives to clear sites, excavations, or obtain raw materials for rock crushers. In doing this, he transfers explosives from magazine to the blasting area; exercises specific safety precautions; bores holes, notes soil formation, determines amount of explosives required; explodes charge by fuse or electrically; oversees stowage of explosives in magazine; and maintains records of explosives expended and in stock. This NEC is assigned only to personnel in paygrades E-5 through E-7 upon satisfactory completion of the applicable course.
3. CRUSHING AND SCREENING PLANT TECHNICIAN (EO-5709) — He supervises site selection, preparation, and setup of crushing/screening/washing plants. In doing this, he selects jaw/roll setting and screens to produce aggregate to specifications; directs and instructs crews in operation, maintenance, lubrication, and operational repairs of plants; and maintains production/distribution records. This NEC is assigned only to personnel in paygrades E-5 through E-7 upon satisfactory completion of the applicable course.
4. GRADE FOREMAN (EO-5711) — He supervises personnel and controls equipment engaged

in excavating, filling, and grading areas to specifications. In doing this, he prepares and works from mass diagrams and construction schedules; computes equipment and material estimates from drawings; sketches, and specifications; uses leveling instruments to set and verify grade stakes; and supervises soil stabilization operations. This NEC is assigned only to E-6 and E-7 personnel upon satisfactory completion of the applicable course.

5. ASPHALT PAVING AND PLANT OPERATING TECHNICIAN (EO-5712)—He supervises site selection, preparation, and setup of bituminous pavement (continuous flow and batch) plants. In doing this, he calibrates and selects screens for continuous flow plant gradation units to produce mixes to design specifications; directs and instructs crews in plant operation, maintenance, and lubrication; prepares and submits production records and reports; supervises and instructs paving crews in hot and cold asphalt paving techniques, including operation, maintenance, and lubrication of equipment; and (prepares) schedules and coordinates support equipment. This NEC is assigned only to personnel in paygrades E-5 through E-7 upon satisfactory completion of the applicable course.

NECs 5707 (Water Well Drilling Technician), 5708 (Blaster), 5709 (Crushing and Screening Plant Technician), and 5711 (Grade Foreman) and their applicable Class "C" course of instruction are given at the EO School, Port Hueneme, California. NEC 5712 (Asphalt Paving and Plant Operating Technician) and its applicable Class "C" course of instruction is given at the EO School, CTU, Gulfport, Mississippi.

6. ADVANCED UNDERWATER CONSTRUCTION TECHNICIAN, BU-5931—He performs underwater construction operations using all types of underwater equipment and tools. In doing this, he plans and supervises simple underwater construction operations; estimates manpower and equipment requirements for various underwater construction projects; inspects material condition, monitors general readiness, diagnoses improper operating procedures and equipment failures.

The NEC BU-5931 is available to personnel in all Group VIII ratings who are graduates of the applicable course of instruction which, at this writing, is under development. The course of instruction, when officially established, will be offered by the Naval Schools Construction at Port Hueneme, California.

7. BASIC UNDERWATER CONSTRUCTION TECHNICIAN, BU-5932—He performs underwater construction operations using common underwater tools, equipment, and materials. In doing this, he performs duties related to underwater construction blasting; component emplacement and assembly; underwater cutting and welding; seafloor surveying; foundations and anchor emplacement; rigging; cable laying and splicing; and system testing.

The NEC BU-5932 is available to personnel in all Group VIII ratings who are graduates of the applicable course of instruction which, at this writing, is also under development. The course of instruction, when officially established, will be offered by the Naval Schools Construction at Port Hueneme, California.

8. SAFETY INSPECTOR, SW-6021—He organizes and supervises the operation of the safety department. In doing this, he investigates accidents and analyzes accidents and problem areas and recommendeds methods to decrease frequency and/or eliminate accidents; collects data to ascertain accident trends; inspects project sites, grounds, buildings and machinery to isolate hazards to life, health, and equipment; conducts safety education campaigns by preparing and/or distributing literature, posters, charts, and displays; organizes and directs safety committee; directs placement of traffic control signs and devices.

The NEC SW-6021 is assigned to personnel in all Group VIII ratings in paygrades E-6 and E-7 who are graduates of the applicable course of instruction. The applicable course is Steelworkers/Safety Inspector, which is given at the Naval Schools Construction at Port Hueneme, California.

9. NUCLEAR POWER PLANT OPERATOR, 3391—He operates, maintains, and performs organizational level maintenance on nonpropulsive nuclear power plants and radioisotope power devices, as an Electrical, Mechanical, Instrument or Health Physics/Plant Chemistry Specialist.

NEC 3391 is normally assigned to personnel in paygrades E4 through E7 who are graduates of the applicable course of instruction. In addition to EOs, this NEC is also available to personnel in the following ratings: UT, CE, CM, SW, and HM. The applicable course of instruction is Nuclear Power Plant Operators. It is offered at the U.S. Naval Nuclear Power Unit at Fort Belvoir, Virginia.

CHAPTER 3

ENGINES, FUELS, LUBRICANTS, AND POLLUTION CONTROL

As an Equipment Operator, you will be mainly concerned with operation of equipment. In order to perform these duties intelligently, it is important that you fully understand the principles of the internal combustion engine operation and the function of the various components that make up the internal combustion engine. This understanding will make your job easier when simple adjustments or repairs have to be made.

This chapter discusses basic principles of engine operation and explains some of the terminology related to engines. Various types of fuel and lubricants are described and information is given on the safe handling and storage of petroleum products. Information is provided on the types and purposes of filters used on automotive and construction equipment. Various methods are discussed on environmental pollution control so that you may effectively control pollution resulting from the combustion and spillage of fuels.

INTERNAL COMBUSTION ENGINES

An internal combustion engine is one in which the fuel burns within the body of the engine. The burning that takes place inside the cylinders produces the energy that turns the crankshaft of the engine. Both gasoline and diesel engines operate on this principle.

Combustion is the act or process of burning. An internal or external combustion engine is defined simply as a machine that converts this heat energy to mechanical energy. To fulfill this purpose, the engine may take one of several forms.

With the internal combustion engine, combustion takes place inside the cylinder and is directly responsible for forcing the piston to move down.

In external combustion engines, such as steam engines, combustion takes place outside the engine. Figure 3-1 shows, in simplified form, an external and an internal combustion engine.

The external combustion engine requires a boiler to which heat is applied. This combustion causes water to boil to produce steam. The steam passes into the engine cylinder under pressure and forces the piston to move downward.

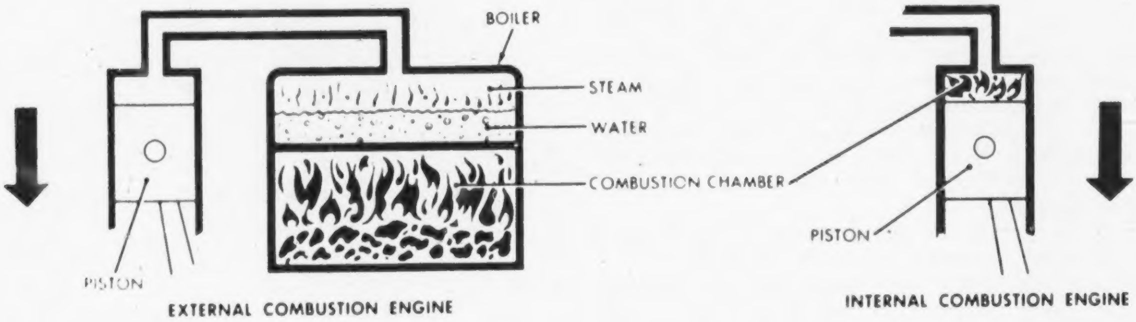
The transformation of HEAT ENERGY to MECHANICAL ENERGY by the engine is based on a fundamental law of physics which states that gas will expand upon application of heat. If the gas is confined with no outlet for expansion, then the pressure of the gas will be increased when heat is applied. In the internal combustion engine the burning of a fuel within a closed cylinder results in an expansion of gases, thus creating a pressure on top of a piston and causing it to move downward.

In an internal combustion engine the piston moves up and down within a cylinder. This up-and-down motion is known as RECIPROCATING MOTION. This reciprocating motion (straight line motion) must be changed to ROTARY MOTION (turning motion) in order to turn the wheels of a vehicle. A crankshaft and a connecting rod change this reciprocating motion to rotary motion, figure 3-2.

All internal combustion engines, whether gasoline or diesel, are basically the same. We can best demonstrate this by saying they all rely on three things—AIR, FUEL, and IGNITION.

FUEL contains potential energy for operating the engine; AIR contains the oxygen necessary for combustion; and IGNITION starts combustion. All are fundamental, and the engine will not operate without any one of them. Any discussion of engines must be based on these three factors and the steps and mechanisms involved in delivering them to the combustion chamber at the proper time.

The power of an internal combustion engine comes from the burning of a mixture of fuel and air in a small, enclosed space. When this



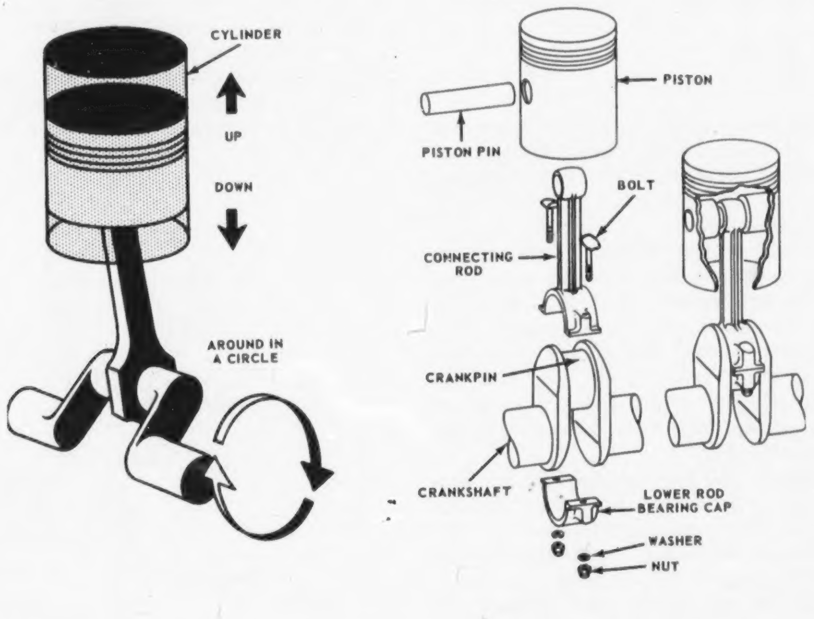
81.41

Figure 3-1. — Simple external and internal combustion engine.

mixture burns it expands greatly, and the push or pressure created is used to move the piston, thereby rotating the crankshaft. This movement is eventually sent back to the wheels to drive the vehicle.

Since similar action occurs in all cylinders of an engine, let's use one cylinder in our development of power. The one-cylinder engine consists of four basic parts as shown in figure 3-2.

First we must have a CYLINDER which is closed at one end; this cylinder is similar to a tall metal can which is stationary within the engine block. Inside this cylinder is the PISTON,



65.95(81C)

Figure 3-2. — Cylinder, piston, connecting rod, and crankshaft for one-cylinder engine.

a movable metal plug, which fits snugly into the cylinder, but can still slide up and down easily.

You have already learned that the up-and-down movement of the piston is called reciprocating motion. This motion must be changed to rotary motion so the wheels or tracks of vehicles can be made to rotate. This change is accomplished by a crank on the CRANKSHAFT and a CONNECTING ROD which connects the piston and the crank.

The crank is an offset section of the crankshaft, which scribes a circle as the shaft rotates. The top end of the connecting rod is connected to the piston and must, therefore, go up and down. The lower end of the connecting rod also moves up and down but, because it is attached to the crankshaft, it must also move in a circle with the crank.

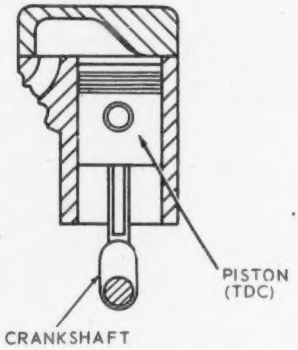
When the piston of the engine slides downward because of the pressure of the expanding gases in the cylinder, the upper end of the connecting rod moves downward with the piston, in a straight line. The lower end of the connecting rod moves down and in a circular motion at the same time. This moves the crank which, in turn, rotates the shaft; this rotation is the desired result. So remember, the crankshaft and connecting rod combination is a mechanism for the purpose of changing straight line (or reciprocating) motion to circular (or rotary) motion.

FOUR-STROKE CYCLE GASOLINE ENGINE

The operating principles of the gasoline and diesel engines are basically the same. Therefore, only the operating cycles of the four-stroke gasoline engine and the two-stroke cycle diesel engines will be discussed.

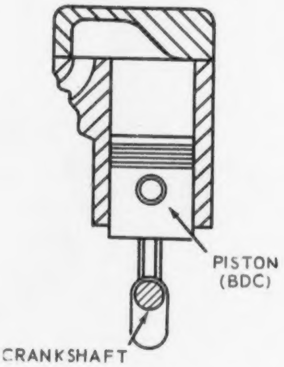
Each movement of the piston from top to bottom or from bottom to top is called a stroke. The piston takes two strokes (an upstroke and a downstroke) as the crankshaft makes one complete revolution. When the piston is at the top of a stroke (fig. 3-3), it is said to be at top dead center (TDC). When the piston is at the bottom of a stroke (fig. 3-4), it is said to be at bottom dead center (BDC).

The basic engine you have studied so far has no provisions for getting the fuel-air mixture into the cylinder or burned gases out of the cylinder. There are two openings in the closed end of a cylinder. One of the openings, permits an intake of air or an intake of a mixture of fuel and air into the combustion area of the cylinder. The other opening permits the burned gases to escape from the cylinder. The two openings have valves in them. These valves, activated by the camshaft, close off either one or the other of the openings, or both of them during various stages of engine operation. The camshaft has a number of cams along its length that open the valves and hold them open for the correct length of time during the piston stroke. The camshaft is driven by the crankshaft through timing gears, or by means of a timing chain. On a 4-stroke cycle engine (fig. 3-5) the camshaft turns at one-half crankshaft speed. This permits each valve to open and close once for every two revolutions of the crankshaft. One of the valves, called the intake valve, opens to admit an intake of air or a mixture of fuel



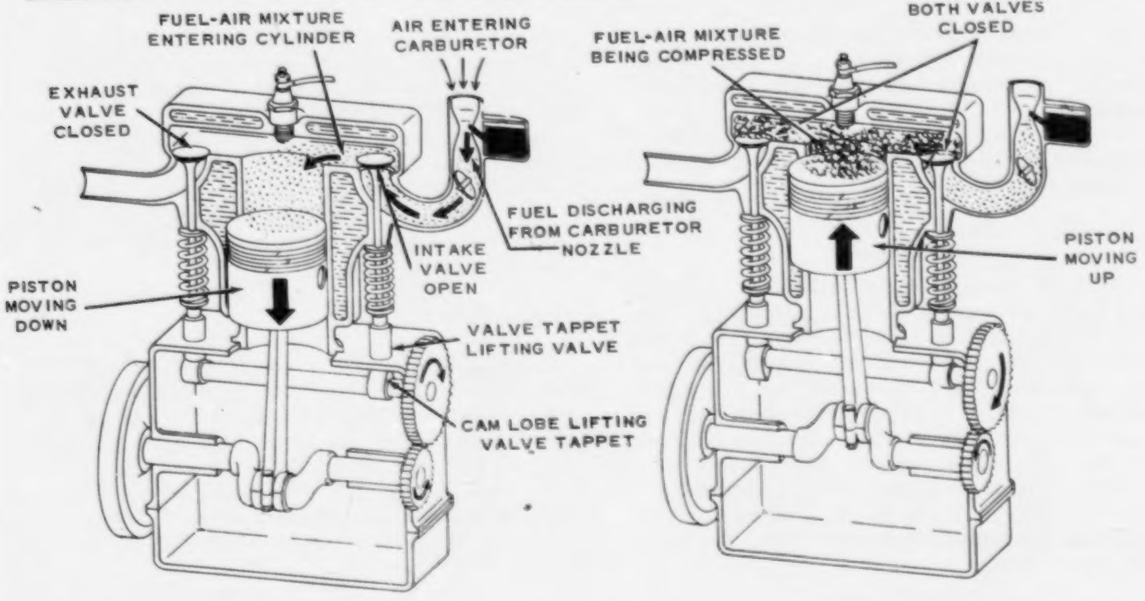
81.42.1

Figure 3-3. — Piston top dead center (TDC).



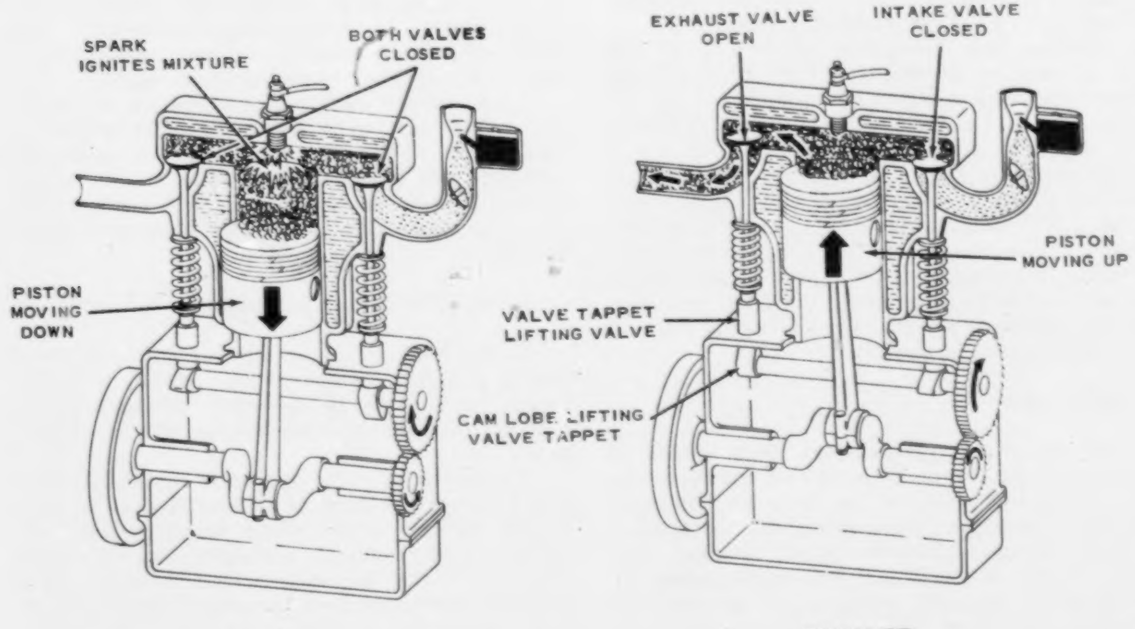
81.42.5

Figure 3-4. — Piston bottom dead center (BDC).


FUEL-AIR MIXTURE ENTERING CYLINDER
AIR ENTERING CARBURETOR
EXHAUST VALVE CLOSED
FUEL DISCHARGING FROM CARBURETOR NOZZLE
INTAKE VALVE OPEN
PISTON MOVING DOWN
VALVE TAPPET LIFTING VALVE
CAM LOBE LIFTING VALVE TAPPET
BOTH VALVES CLOSED
FUEL-AIR MIXTURE BEING COMPRESSED
PISTON MOVING UP

INTAKE

COMPRESSION



POWER

EXHAUST

Figure 3-5. — Four-stroke cycle in a gasoline engine. 54.19(65B)

and air into the cylinder. The other valve, called the exhaust valve, opens to allow the escape of burned gases after the fuel-and-air mixture has burned.

The following paragraphs give a simplified explanation of the action that takes place within the engine cylinder.

Intake Stroke

The first stroke in the sequence is called the INTAKE stroke (fig. 3-5). During this stroke, as the crankshaft continues to rotate, the piston is moving downward and the intake valve is open. This downward movement of the piston produces a partial vacuum in the cylinder, and an air-fuel mixture rushes into the cylinder past the open intake valve. This is somewhat the same effect as when you drink through a straw. A partial vacuum is produced in the mouth and the liquid moves up through the straw to fill the vacuum.

Compression Stroke

When the piston reaches bottom dead center at the end of the intake stroke and is therefore at the bottom of the cylinder, the intake valve closes. This seals the upper end of the cylinder. As the crankshaft continues to rotate, it pushes up, through the connecting rod, on the piston. The piston is therefore pushed upward and compresses the combustible mixture in the cylinder; this is called the COMPRESSION stroke (fig. 3-5). In gasoline engines, the mixture is compressed to about one-eighth of its original volume, which is called an 8 to 1 compression ratio. This compression of the air-fuel mixture increases the pressure within the cylinder. Compressing the mixture in this way makes it still more combustible; not only does the pressure in the cylinder go up, but the temperature of the mixture also increases.

Power Stroke

As the piston reaches top dead center at the end of the compression stroke and therefore has moved to the top of the cylinder, the compressed fuel-air mixture is ignited. The ignition system causes an electric spark to occur suddenly in the cylinder, and the spark ignites the compressed fuel-air mixture. In burning, the mixture gets very hot and tries to expand in all directions. The pressure rises to about 600 to 700 pounds per square inch. Since the piston is the only thing that can move, the force produced by the expanding gases forces the piston down. This force, or thrust, is carried through the connecting rod to the crankpin on the crankshaft. The crankshaft is given a powerful turn. This is called the POWER stroke (fig. 3-5). This turning effort, rapidly repeated in the engine and carried through gears and shafts, will turn the wheels of a vehicle and cause it to move along the highway.

Exhaust Stroke

After the fuel-air mixture has burned, it must be cleared from the cylinder. This is done by opening the exhaust valve just as the power stroke is finished and the piston starts back up on the EXHAUST stroke (fig. 3-5). The piston forces the burned gases out of the cylinder past the open exhaust valve.

ENGINE CYCLES

The four strokes (intake, compression, power, and exhaust) are continuously repeated as the engine runs. Now, with the basic knowledge you have of the parts and the four strokes of the engine, let us see what happens during the actual running of the engine. To produce sustained power, an engine must accomplish the same series of events — intake, compression, power, and exhaust — over and over again.

This series of events is called a cycle. Remember that in a 4-stroke cycle engine it takes four complete strokes of the piston to complete one engine cycle, that is, two complete revolutions of the crankshaft. Most engines that you will deal with are of the 4-stroke cycle design.

2-Stroke Cycle Diesel Engine

In the 2-stroke cycle engine, the same four events (intake, compression, power, and exhaust) take place in only two strokes of the piston; one complete revolution of the crankshaft.

The 2-stroke cycle operation shown in figure 3-6 features the General Motors 71 series. This engine differs in two ways from the 4-stroke cycle engine previously discussed. Not only does it complete the four events in 2-strokes, but it depends upon the heat of compression rather than a spark for ignition. In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively.

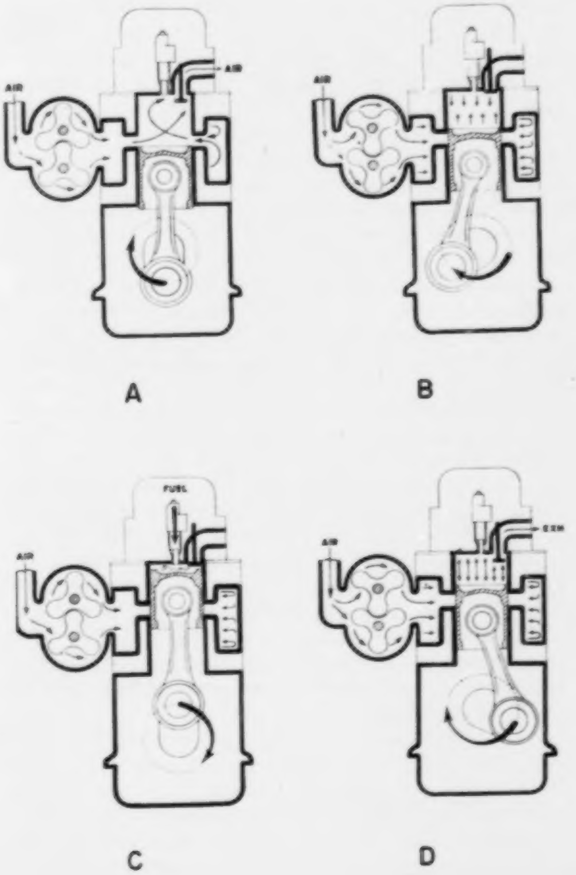


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Figure 3-6.—Events in a 2-stroke cycle, internal combustion engine.

In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle. A blower is provided to force air into the cylinders for expelling the exhaust gases and supply the cylinders with fresh air for combustion. The cylinder walls contain a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the top face of the piston uncovers the ports, as shown in view A, figure 3-6. The indirectional flow of air toward the exhaust valves produces a scavenging effect; this action leaves the cylinder full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves (2 per cylinder) close and the charge of fresh air is subject to compression, as shown in view B, figure 3-6. Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion space by the cylinder's injector, view C, figure 3-6; the intense heat generated during the high compression of the air ignites the fine spray immediately and the combustion continues as long as the fuel spray lasts. The resulting pressure forces the piston downward on the power stroke. The exhaust valves are again opened when the piston is about halfway down, allowing the combustion gases to escape into the exhaust manifold, view D, figure 3-6. Shortly thereafter, the downward movement of the piston uncovers the inlet ports and the cylinder is again swept with clean air, as shown in view A, figure 3-6. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft and during two strokes of the piston thus; the term "two-stroke cycle."

4-Stroke Cycle Vs
2-Stroke Cycle

A power stroke is produced every crankshaft revolution within the 2-stroke cycle engine; whereas the 4-stroke cycle engine requires two crankshaft revolutions for one power stroke.

It might appear then that a 2-stroke cycle could produce twice as much power as a 4-stroke cycle of the same size, operating at the same speed. However, this is not true. With some 2-stroke cycle engines, some of the power is used to drive a blower that forces the air-fuel charge into the cylinder under pressure. Also, the burned gases are not completely cleared from the cylinder, reducing combustion efficiency. Additionally, because of the much shorter period the intake port is open (as compared to the period the intake valve in a 4-stroke-cycle is open), a relatively smaller amount of fuel-air mixture is admitted. Hence, with less fuel-air mixture, less power per power stroke is produced in a 2-stroke cycle engine of like size operating at the same speed and with other conditions being the same.

MULTIFUEL ENGINE

The multifuel engine operates on a compression ignition, four-stroke cycle principle similar to conventional four-stroke cycle diesel and gasoline engines. Those pieces of military equipment which are equipped with the multifuel engine are designed to use several different types of fuel, such as gasoline, kerosene, diesel, and (JP) fuels. No modifications or adjustments are necessary when changing grades or types of fuel.

The multifuel engine operation cycle, is shown in figure 3-7.

STARTING AND STOPPING PROCEDURES FOR GASOLINE AND DIESEL ENGINES

In the previous sections you learned about the operating cycle of the internal combustion engine, and how it is constructed.

In order to make the basic engine operational, it requires the addition of cooling, lubrication, fuel, and electrical systems. Before starting an internal combustion engine, certain pre-start checks must be made to determine if the engine will operate. Check for fuel, coolant, battery condition, loose wires, oil level, and the absence of leaks.

In this chapter, it is infeasible to state the correct procedures for starting and stopping every type of automotive or construction equipment, equipped with a gasoline or diesel engine that is used in the Navy. Therefore, the procedures explained below apply to typical types of automotive equipment equipped with a gasoline engine. For information on a specific type of automotive vehicle consult the manufacturers operating manual. Procedures for starting and stopping a typical piece of construction equipment equipped with a diesel engine are covered in chapter 9.

Before starting the engine, be sure the hand or parking brake is set, and the gear selector lever is in NEUTRAL. On a vehicle with an automatic transmission, set the lever at N (NEUTRAL) or push in the N (NEUTRAL) button; otherwise the engine will not start. Some vehicles can be started also in P (PARK).

Next, turn on the ignition and depress the accelerator one-quarter of the way toward the floor. If the equipment has a clutch, disengage it before starting the engine to ensure that the vehicle will not move, and to keep the starter from turning the transmission.

If the engine does not have an automatic choke, pull the choke control out about half-way. Using the choke when the engine is warm will cause flooding and will hinder easy starting.

Now operate the starter until the engine begins to fire. The starter on some vehicles may be actuated by pushing in a starter button on the instrument panel; on others, by depressing the starter button on the floorboard. A few engines are started by depressing the accelerator pedal; on others, turning the ignition switch key to the extreme right starts the engine.

If the engine does not start within 10 seconds, stop to see whether you have properly performed all prestarting operations. If it does not start after several attempts, notify your chief.

Caution: Never operate the cranking motor for more than 30 seconds at a time. If the engine fails to start in 30 seconds, allow the cranking motor to cool for 2 to 3 minutes before resuming cranking operation. Prolonged use of the starter wears it out and discharges the battery.

As soon as the engine begins to fire, release the starter knob, or let the ignition switch key snap back to ON position. Release the clutch pedal slowly, if you have depressed it, and push the choke control back in. After the engine is operating smoothly, ease off the throttle, and allow the engine to idle till it warms to the proper operating temperature. The warm-up period allows the oil in the crankcase to circulate and lubricate the engine pistons, bearings, and the cylinder surfaces. Putting a vehicle into motion before the engine is at proper operating temperature will cause undue wear of the moving parts of the engine.

The following are typical procedures for stopping automotive gasoline engines: (1) Allow the engine to operate at low idle for 3 to 5 minutes, (2) check gage readings; for water coolant within normal range, lubricating oil pressure within range, ammeter showing a charge, fuel gage indicating sufficient fule, and air pressure gage (if so equipped) indicating normal air pressure, and (3) turn the electrical system ignition switch to the OFF position.

FUELS AND LUBRICANTS

Fuels and lubricants for gasoline and diesel engines are byproducts of petroleum. Petroleum, often called crude oil, means "rock oil." Petroleum products include gasoline, kerosene, diesel fuel, lubricating oils, gear lubricants, and greases. Many different products are added to the raw byproducts to obtain a fuel or lubricant that will perform efficiently in modern equipment.

Crude oil would ruin an engine if the impurities were not removed. The impurities are removed by the refining process, which also

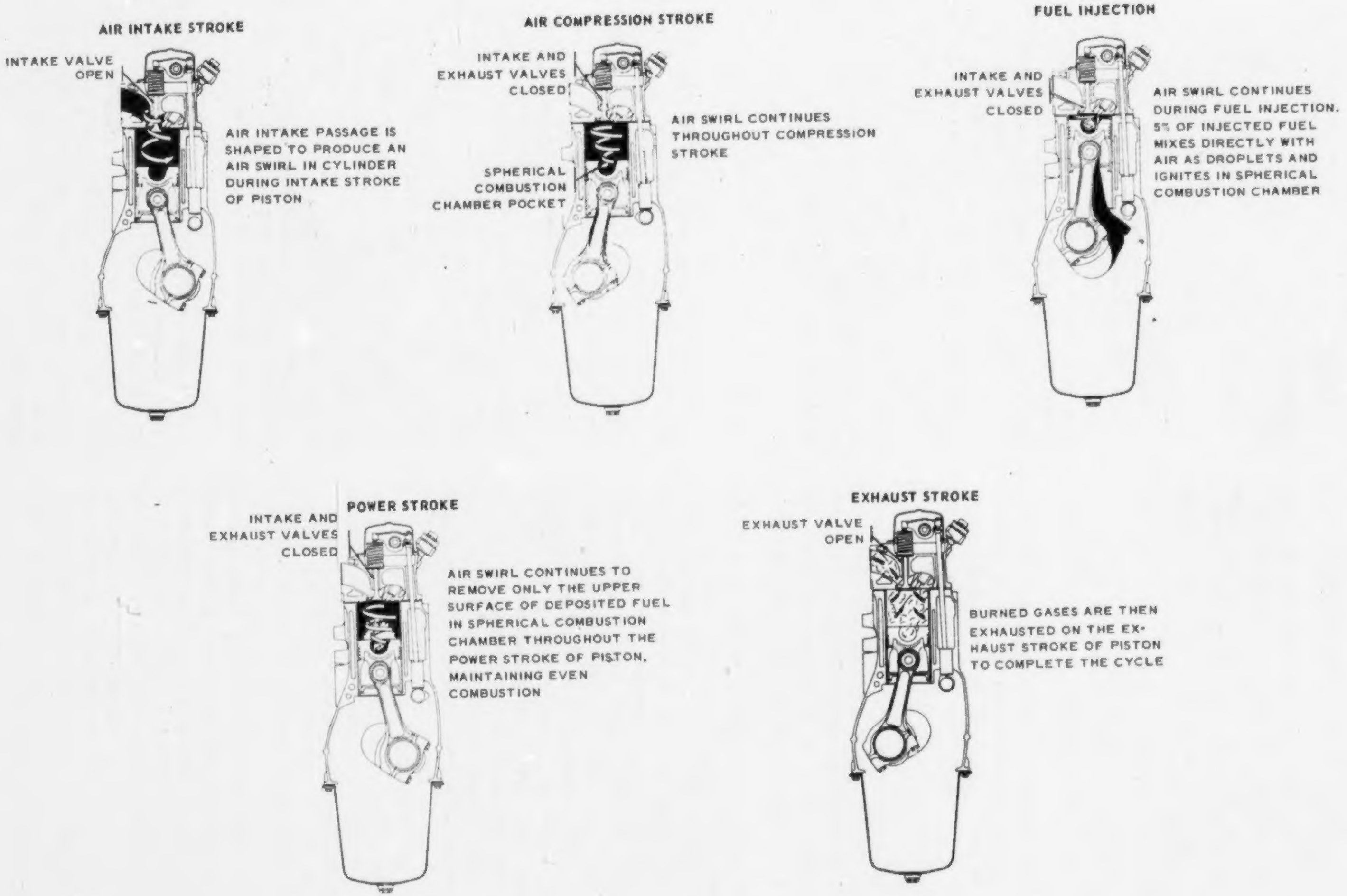
AIR INTAKE STROKE
INTAKE VALVE OPEN
AIR INTAKE PASSAGE IS SHAPED TO PRODUCE AN AIR SWIRL IN CYLINDER DURING INTAKE STROKE OF PISTON
AIR COMPRESSION STROKE
INTAKE AND EXHAUST VALVES CLOSED
AIR SWIRL CONTINUES THROUGHOUT COMPRESSION STROKE
SPHERICAL COMBUSTION CHAMBER POCKET
FUEL INJECTION
INTAKE AND EXHAUST VALVES CLOSED
AIR SWIRL CONTINUES DURING FUEL INJECTION. 5% OF INJECTED FUEL MIXES DIRECTLY WITH AIR AS DROPLETS AND IGNITES IN SPHERICAL COMBUSTION CHAMBER
POWER STROKE
INTAKE AND EXHAUST VALVES CLOSED
AIR SWIRL CONTINUES TO REMOVE ONLY THE UPPER SURFACE OF DEPOSITED FUEL IN SPHERICAL COMBUSTION CHAMBER THROUGHOUT THE POWER STROKE OF PISTON, MAINTAINING EVEN COMBUSTION
EXHAUST STROKE
EXHAUST VALVE OPEN
BURNED GASES ARE THEN EXHAUSTED ON THE EXHAUST STROKE OF PISTON TO COMPLETE THE CYCLE

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Figure 3-7.—Multifuel engine operation cycles.

separates the oil into various petroleum products. (See fig. 3-8.)

You have seen a teakettle boil. Heating the water in the kettle changes it to gas or vapor in the form of steam at a certain temperature. Many kinds of liquids change to gases, or are said to VAPORIZE, at different temperatures. Heating petroleum, which is a mixture of liquids, will change the liquids to gases one by one. Cooling changes each gas back to liquid form through condensation. This process of separating substances from one another is called DISTILLATION.

Distillation drives gasoline vapors from the crude oil first, because gasoline has a lower boiling point and vaporizes before other petroleum products. Substances with higher boiling points, like kerosene and the gas-oil from which we get most of our diesel fuel, are given off next. After the gas-oil has been collected, lubricating oils are distilled, the lightest first (lube distillates), and then the heavier ones (commonly called bottoms). (It is to be noted, bottoms are where we get asphaltic products.) (See fig. 3-8.)

You will hear also about propane and butane fuels, which are byproducts of natural gas. (Notice in figure 3-8 that gas is taken from a cavity in the earth that is between the oil and the rock formation just above the oil.) These liquids must be collected and stored under pressure because they change into gas when released to the atmosphere. Liquid propane becomes a gas at a temperature of -43°F; liquid butane, at -33°F. Although seldom used as a fuel for automotive equipment, small amounts of these liquid gases have been used to start engines in very cold climates. Some manufacturers believe that internal combustion engines can operate more economically with butane fuel than with gasoline. Gasoline and diesel oil, however, continue to be the most common fuels for internal combustion engines.

PROPERTIES OF GASOLINE

Gasoline contains carbon and hydrogen in such proportions that the gasoline burns freely and liberates HEAT ENERGY. If all the potential heat energy contained in a gallon of gasoline could be converted into work, a motor vehicle could run hundreds of miles on each gallon. However, only a small percentage of this heat energy is converted into power by the engine. Most authorities consider the power losses within the engine to be as follows:

Engine	Percent of Power Loss
Cooling System	35
Exhaust Gases	35
Engine Friction	5 to 10
Total	75 to 80

The question of what is ideal gasoline is more theoretical than practical. Every manufacturer recommends the octane rating of the gasoline he feels is best for the engines he produces. Besides engine design, factors like the weight of the vehicle, the terrain and highways over which it is to be driven, and the climate and altitude of the locality also determine what gasoline is best to use. All other factors being equal, these may be considered as some of the properties of the best gasoline: good antiknock quality, a minimum content of foreign matter, and a volatility which makes starting easy and allows smooth acceleration and economical operation.

Volatility

The blend of a gasoline determines its VOLATILITY—that is, its tendency to change from a liquid to a vapor at any given temperature. The rate of vaporization increases as the temperature of the gasoline rises.

No standard for gasoline volatility meets all engine operating requirements. The volatility must be high enough for easy starting and acceleration. Ordinarily the proper starting mixture is about 15 parts of air to 1 part of fuel, but in very cold weather more fuel must be admitted to the cylinders through the use of the choke in the carburetor for quicker starting. In polar regions, a gasoline of higher volatility makes starting easier; it also helps keep the crankcase from becoming diluted by gasoline seeping past the piston and the piston rings while the engine is being choked.

On the other hand, a gasoline of low volatility brings about better fuel economy and combats VAPOR LOCK (the formation of vapor in the fuel lines in a quantity sufficient to block the flow of gasoline through the system). In the summer and in hot climates, especially, fuels with low volatility lessen the tendency toward vapor lock.

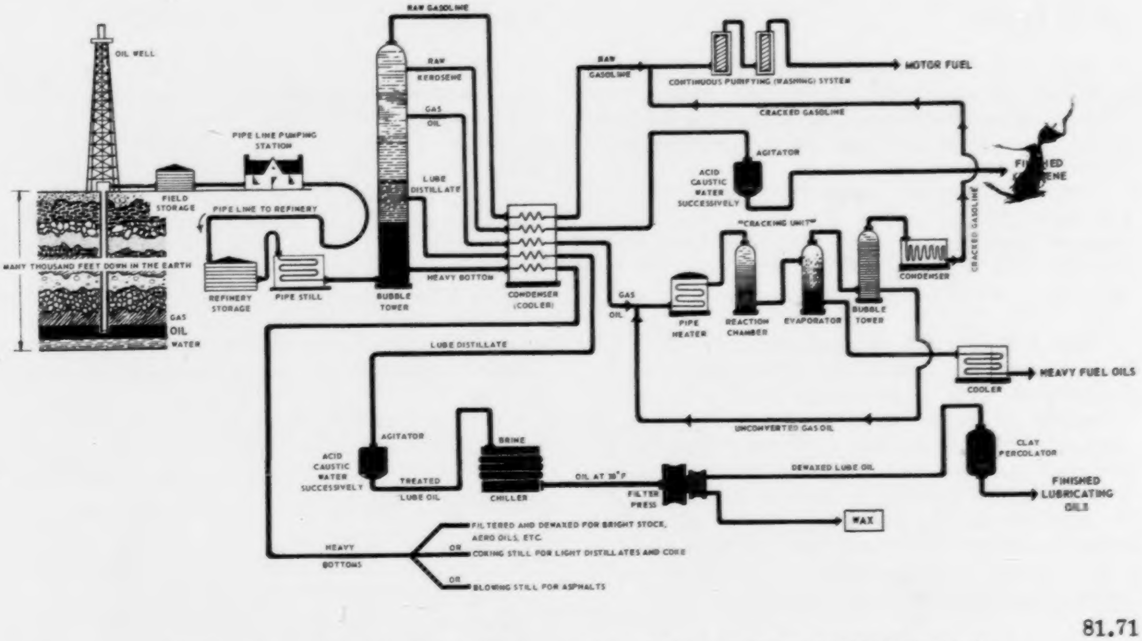

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Figure 3-8. — Typical chart tracing crude oil from well to finished product.

Purity

Engine efficiency depends to some extent on the PURITY of gasoline. Gums and sulfur are removed from crude oil in the refining process. Gums in gasoline cause sticking valves and form hard baked surfaces within the cylinders. Residue unites with moisture to form sulfuric acid, which corrodes engine parts. Modern refining processes have reduced the sulfur and other foreign matter content of gasoline, thus minimizing the damage to engine parts as well as cutting down engine maintenance.

Antiknock Quality and Detonation

Reviewing the process of combustion will help you understand the ANTIKNOCK quality of gasoline. When any substance burns, its molecules and those of the oxygen in the air around it are set into motion, producing heat that unites the two groups of molecules in a rapid chemical reaction. In the combustion chamber of an engine cylinder, the gasoline vapor and oxygen in the air are ignited and burn. They combine, and the molecules begin to move about very rapidly, as the high temperatures of combustion are reached. This rapid movement of molecules provides the push on the piston to force it downward on the power stroke.

In the modern high compression gasoline engines the air-fuel mixture tends to ignite spontaneously or to explode instead of burning. The result is a knock, a ping, or a DETONATION. In detonation the spark from the spark plug starts the fuel mixture burning, and the flame spreads through the layers of the mixture, very quickly compressing and heating them. The last layers become so compressed and heated that they explode violently. The explosive pressure strikes the piston head and the walls of the cylinder, and causes the knock you hear in the engine. It is the fuel, not the engine, that knocks. Besides being an annoying sound, persistent knocking results in engine overheating, loss of power, and increased fuel consumption. It causes severe shock to the spark plugs, pistons, connecting rods, and the crankshaft. To slow down this burning rate of the fuel, a fuel of a higher octane rating must be used.

Octane Rating

The property of a fuel to resist detonation is called its antiknock or OCTANE rating. The octane rating is obtained by comparing the antiknock qualities of gasoline in a special test engine against reference fuels.

Octane numbers range from 50 in cheaper gasolines to over 100 for those required of modern high compression engines. The octane number has nothing to do with the starting qualities, potential energy, or volatility of the fuel.

The octane rating of gasoline can be raised in two ways: by mixing it with another fuel, or treating it with a chemical. In this country a chemical is added to gasoline to improve its octane rating. The most efficient additive used for this purpose is tetraethyl lead compound, which is added to the gasoline with ETHYL FLUID. In addition to the tetraethyl lead, ethyl fluid contains other chemicals that prevent lead deposits from forming within the engine. Lead oxide causes considerable corrosion.

The LEAD CONTENT of ethyl fluid is very poisonous. Ethyl gasoline should be used only for engine fuel and for no other purpose. It should never be used as a cleaning agent.

An engine which does not knock on a low octane fuel will not operate more efficiently by using a fuel of high octane rating. An engine which knocks on a given fuel should use one of a higher rating. If a higher octane fuel does not stop the knocking, some mechanical adjustments are probably necessary. Retarding the spark so that the engine will fire later may end knocking. However, an engine operating on retarded spark will use more fuel and will overheat. It may be less expensive to use a higher priced, high-octane gasoline with an advanced spark than to use a cheap, low-octane gasoline with a retarded spark.

Engine knocking is not always the result of using too low an octane rating; it can be caused by preignition. In preignition the fuel-air mixture begins to burn before the spark occurs. This condition may be caused by an overheated exhaust valve head, hot spark plugs, or glowing pieces of carbon within the combustion chamber. In figure 3-9, you see the diagrammed course of the fuel-air mixture in the cylinder under circumstances of preignition and detonation, as well as in normal combustion.

DIESEL FUEL

Diesel fuel is heavier than gasoline because it is obtained from the residue of the crude oil after the more volatile fuels have been removed. As with gasoline, the efficiency of a diesel fuel varies with the type of engine in which it is used. By distillation, cracking, and blending of several oils, a suitable diesel fuel can be obtained for almost all engine operating conditions. Slow speed diesels use a wide variety of heavy fuels; high speed diesel engines require a lighter fuel. Using a poor or an improper grade of fuel can cause hard starting, incomplete combustion, a smoky exhaust, and engine knocks.

The properties to be considered in selecting a fuel for a diesel engine are VOLATILITY, CLEANLINESS, VISCOSITY, AND IGNITION QUALITY.

Volatility

The volatility of a diesel fuel is measured by the 90 percent distillation temperature. This is the temperature at which 90 percent of a sample of the fuel has been distilled off. The lower this temperature, the higher the volatility of the fuel. In small diesel engines, a fuel of high volatility is more necessary than in large engines if there is to be low fuel consumption, low exhaust temperature, and little exhaust smoke.

Cleanliness

Cleanliness of diesel fuel is very important. Fuel should not contain more than a trace of foreign substances; otherwise, fuel pump and injector difficulties will develop. Because it is heavier and more viscous, diesel fuel will hold dirt particles in suspension for longer periods than will gasoline. In the refining process, not all foreign matter can be removed, and harmful matter like dirt and water can get into the fuel while it is being handled. Water will cause hard starting and misfiring. Dirt will clog injectors and spray nozzles and may cause an engine to misfire or stop altogether.

Viscosity

The viscosity of fuel is the measure of its resistance to flow. Viscosity is expressed by the number of seconds required for a certain volume of fuel to flow through a hole of a certain diameter at a given temperature. The viscosity of diesel duel must be low enough to flow freely at low temperatures, yet high enough to lubricate the pump and injector plungers properly and lessen the possibility of leakage at the pump plungers and dribbling at the injectors. Viscosity is measured by an instrument (fig. 3-10) called the SAYBOLT VISCOSIMETER and is expressed in SAYBOLTSECONDS, UNIVERSAL (SSU).

A Saybolt viscosimeter consists of an oil tube, a constant-temperature oil bath which maintains the correct temperature of the sample in the tube, a 60-cc (cubic-centimeter) graduated receiving flask, thermometers for measuring the temperature of the oil sample and of the oil bath, and a timing device.

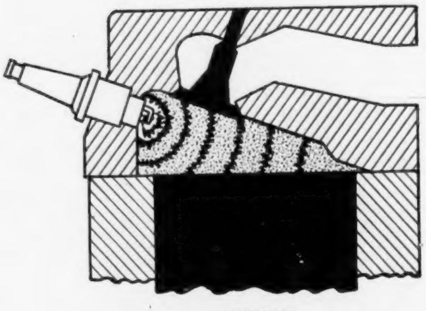
The oil to be tested is strained and poured into the oil tube. The tube is surrounded by the constant-temperature oil bath. When the oil sample is at the correct temperature, the cork is pulled from the lower end of the tube and the sample flows through the orifice and into the graduated receiving flask. The time (in seconds) required for the oil to fill the receiving flask to the 60-cc mark is noted.

The viscosity of the oil is expressed by indicating three things: first, the number of seconds required for 60 cubic centimeters of oil to flow into the receiving flask; second, the type of orifice used; and third, the temperature of the oil sample at the time the viscosity determination is made. For example, suppose that a sample of lubricating oil is heated to 125°F and that 170 seconds are required for 60-cc of the sample of flow through a Saybolt Universal orifice and into the receiving flask. The viscosity of this oil is said to be 170 seconds Saybolt Universal at 125°F. This is usually expressed in shorter form as 170 SSU at 125°F (or 20 weight oil.)

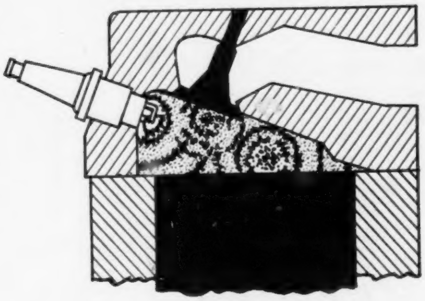
Other oils have other temperatures that are used for obtaining Saybolt Universal viscosities. Thus, it is important that the temperature be included in the statement of viscosity.

Ignition Quality

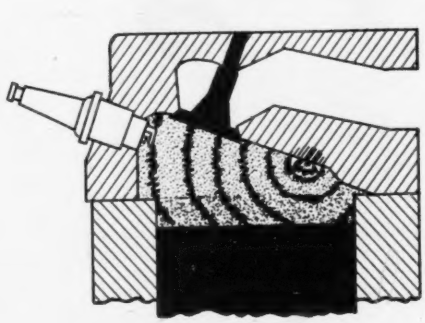
The ignition quality of a diesel fuel is its ability to ignite when it is injected into the compressed air within the engine cylinders. Ignition quality is measured by the CETANE RATING of the fuel. A cetane number is obtained by comparing the ignition quality of a given diesel fuel with that of a reference fuel of known cetane number in a test engine. This reference fuel is a mixture of alphamethylnapthalene, which is difficult to ignite alone, and cetane, which



NORMAL



DETONATION



PREIGNITION

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Figure 3-9.—Combustion process.

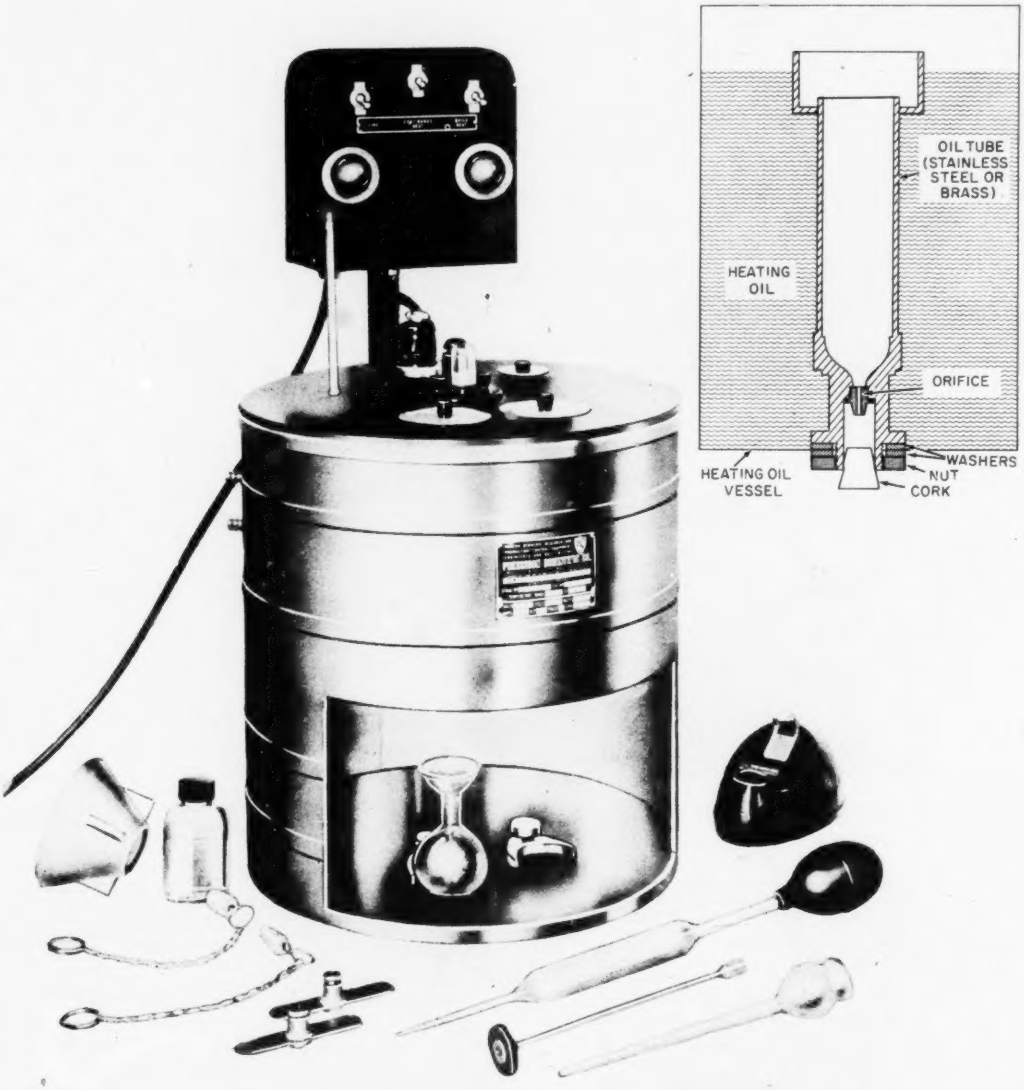

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Figure 3-10.—Saybolt viscosimeter.

will ignite readily at temperatures and pressures comparable to those in the cylinders of a diesel engine. The cetane rating indicates the percentage of cetane in a reference fuel which will just match the ignition quality of the fuel being tested. The higher cetane numbers indicate more efficient fuels. The large slow diesels can use a 30 cetane fuel, but the high speed diesels must use at least a 40 cetane fuel, while some require as high as a 60 cetane fuel.

The ignition quality of a diesel-fuel depends also on its FLASH POINT and its FIRE POINT. The flast point is the temperature to which the fuel vapors must be heated to flash or ignite. The minimum flash point for diesel fuel is 150°

F. A fuel having too low a flash point is dangerous both to handle and to store.

The fire point is that temperature at which the fuel vapors will continue to burn after being ignited. It is usually 10 to 70 degrees higher than the flash point.

You will sometimes hear knocks in diesel engines. They are believed to be caused by the rapid burning of the fuel that accumulates in the delay period between injection and ignition. This delay is known as IGNITION LAG or IGNITION DELAY. When the fuel is injected into the cylinders, it must vaporize and be heated to the flash point to start combustion. The lag between vaporization and flash point depends upon the ignition quality of the fuel and the speed of the engine and its compression ratio. In high speed engines the delay varies from 0.0012 to 0.0018 of a second. Ignition lag decreases with the increase in engine speed because of a swifter air movement in the cylinders that makes the injected fuel heat better.

LUBRICANTS

A lubricant is a substance, usually a thin film of oil, used to reduce friction. There are three types of kinetic friction: sliding friction, rolling friction, and fluid friction. Sliding friction exists when the surface of one solid body is moved across the surface of another solid body. Rolling friction exists when a curved body such as a cylinder or a sphere rolls upon a flat or curved surface. Fluid friction is the resistance to motion exhibited by a fluid.

Fluid friction exists because of the cohesion between particles of the fluid and the adhesion of fluid particles to the object or medium which is tending to move the fluid. If a paddle is used to stir a fluid, for example, the cohesive forces between the molecules of the fluid tend to hold the molecules together and thus prevent motion of the fluid. At the same time, the adhesive forces of the molecules of the fluid cause the fluid to adhere to the paddle and thus create friction between the paddle and the fluid. Cohesion is the molecular attraction between particles that tends to hold a substance or a body together; adhesion is the molecular attraction between particles that tends to cause unlike surfaces to stick together. From the point of view of lubrication, adhesion is the property of a lubricant that causes it to stick (or adhere) to the parts being lubricated; cohesion is the property which holds the lubricant together and enables it to resist breakdown under pressure.

Besides reducing friction and wear, lubricants act as COOLING AGENTS, absorbing heat from the surfaces over which they are spread. This is true particularly of engine oil, which carries heat to the engine sump, where it is dissipated. The water circulating through an oil cooler also helps to reduce this heat (not all engines have oil coolers).

Lubricants are also used as SEALING agents. They fill the tiny openings between moving parts, cushioning them against damage and distortion from extreme heat.

Lubricants are also important as CLEANING AGENTS. Any grit and dirt finding their way into the engine parts often are removed by the lubricants before damage can result. Foreign matter found in old oils and greases in the bottom of the crankcase is evidence of the cleansing quality of lubricants. Some lubricants have chemicals added to make them better cleaners.

The high temperatures, speeds, and cylinder pressures of modern engines have made necessary better grades of lubricating oils. To increase efficiency, certain chemicals, called ADDITIVES, are put into oils. Additives are resistive agents which are used against oxidation and other kinds of metal deterioration. Oil which contains additives specifically designed to help clean the piston rings and other parts of the engine as it lubricates is known as DETERGENT OIL.

It is especially important for you to keep up with the latest developments in lubricants as presented in Navy and other technical publications. Your chief will tell you where you can get this information.

Types of Lubricants and Their Uses

Oils and greases are the two general types of lubricants. The modern high-speed gasoline or diesel engine must be properly lubricated with the proper grades and types of lubricating oils and greases. Present-day refining methods have produced lubricating oils and greases with certain special qualities. In engines operating at high speeds and temperatures, these oils do a better job than ordinary oils can do. Engines operating at low speeds or in cold weather may require an oil with other special qualities.

Greases are used where it is difficult to keep oil in place and where the lubricant is subjected to varying pressures. In some cases, greases are used when centrifugal forces tend to throw the lubricant from moving parts. This is especially true in gear boxes and wheel bearings.

OILS.—Lubricating oils serve four purposes: (1) prevent metal-to-metal contact in moving parts of mechanisms, (2) help carry heat away from the engine, (3) clean the engine parts as they are lubricated, and (4) form a seal between moving parts. Moving parts that do not have enough oil will melt, fuse, or seize after a very short period of engine operation. All gears and accessory drives, as well as other moving parts of the engine subject to friction, must be bathed in oil at all times.

We have seen that viscosity is the resistance of a liquid against flow. It is the most important property of a lubricating oil. A lubricant of high viscosity spreads very slowly. You have heard of car owners using a HEAVY oil in summer and changing to LIGHT oil in winter. The heavy oil used in summer becomes too sluggish in cold weather, while the light oil used in winter flows too easily in hot weather. An oil used in any engine must flow freely and have enough body to resist friction between moving engine parts; it must pass readily through all oil lines and spread effectively over all surfaces that require lubrication.

The temperature of an oil affects its viscosity. The higher the temperature, the lower the viscosity. On a cold morning, the high viscosity or stiffness of the lubricating oil makes an engine hard to turn over.

The viscosity of an oil is figured by the number of seconds which pass while a certain volume flows through a small opening or hole of a definite diameter at a given temperature. The greater the number of seconds, the higher the viscosity. The Society of Automotive Engineers (S.A.E.) has standardized a code of numbers to indicate the viscosity of lubricating oils. You will be using military symbols for these lubricating oils, which are expressed in four digits, as indicated in Table 3-1. The last three digits indicate the viscosity in number of seconds required for 60 cubic centimeters of oil to flow through a standard opening at a given temperature. The first digit indicates the class and type of lubricating oil. You will use only the lubricant recommended for the particular engine which you service and lubricate. It is advisable to check with your chief from time to time for discontinued and new stocks and changed designations or specification numbers.

Oil is a mixture of many slightly different compounds, and therefore does not have a definite freezing point, but it does thicken as it cools. In order to determine the usefulness of an oil in cold weather, it is tested for its POUR POINT, which is the lowest temperature at which the oil will still flow. The pour point in which you will be interested is the lowest temperature at which the oil on the cylinder walls and bearings will permit the engine to be turned.

While the flash point and the fire point of an oil do not affect its lubricating qualities, they are useful in determining the amount of volatile fluids or compounds in the oil. As you learned concerning diesel oil, the flash point is the temperature at which vapors will ignite, but not sustain a flame. The flash point of a lubricating oil for your entire engine must range from 300°F to 500°F to keep the oil from vaporizing too readily in the crankcase and to make it withstand the heat of the engine. It is used also to determine the fire hazard in shipping and storing the lubricant.

Again, as you previously learned, the fire point is the temperature at which vapors given off continue to burn when ignited. Both the flash point and the fire point must be taken into consideration in the blending of an oil of proper viscosity for the type and condition of the engine in which it is to be used.

From the day that fresh oil is put into the engine crankcase, it gradually begins to lose its effectiveness because of dilution and contamination from engine operation. Gasoline or diesel fuel may dribble into the crankcase oil. Water and sludge also may accumulate. Carbon, gum acids, and dust in the air entering the engine (in the air-fuel mixture) all reduce the effectiveness of any lubricant. It is because of this accumulation of foreign matter that manufacturers recommend regular oil changes, and that regular lubrication is so important in preventive maintenance.

GREASES.—Greases are compounds of oil and soap. The soaps used are not ordinary laundry soaps but animal fats mixed with certain chemicals. The chief purpose of the soap is to provide a body or carrier for the oil that actually does the lubricating.

Grease is used where oil is impractical or unsatisfactory due to centrifugal forces, loads, temperatures or exposure. For instance, it maintains a film at high engine speed and temperature, or when the equipment is idle for long periods of time.

The chemicals in the grease classify it for a particular purpose or use. CHASSIS GREASES have a lime, sodium, or an aluminum soap base. Chassis greases are distinguished by their shiny, transparent appearance, and are used as a pressure gum lubricant for chassis, U-joints, track rollers, and low temperature ball bearings.

CUP GREASE, or WATER-PUMP GREASE, is a lime-base grease to which water or moisture is added to keep the soap from separating from the oil. The moisture gives the grease a somewhat cloudy appearance, and it will evaporate at a temperature equal to that of boiling water. Lime base greases are not recommended for parts subjected to high temperature. These greases are recommended when moisture resistance is required, and are satisfactory for water pumps and marine stuffing boxes.

WHEEL BEARING or FIBROUS GREASES have a sodium or mixed soap base. These greases only appear fibrous, for there are no actual fibers in them. They are recommended for wheel bearings because they stick or cling to parts. Since they are not water resistant, they can be used only on protected parts.

CABLE GREASE (wire rope and exposed gear grease) is a sticky black oil used to lubricate chains and wire ropes.

The black, tar-like sticky mass called CRATER COMPOUND is used to grease sliding surfaces and exposed gears on heavy duty construction equipment. It is applied by hand or with a brush and cannot be squeezed from between the gear teeth or the sliding surfaces. You will find a can of this grease on nearly every shovel or crane used by the Navy.

Some form of dry lubricant such as GRAPHITE POWDER is available in the shop, to lubricate small parts and door locks, where a liquid would run off or otherwise be undesirable.

Petroleum refiners have developed greases to meet special lubrication requirements of modern machinery and equipment. Table 3-2 lists and describes the kinds of greases and their uses for proper maintenance.

CONTAMINATION OF PRODUCTS

A contaminated product is one to which has been added some material not normally present such as dirt, rust, water, or another petroleum product. Such admixture may modify the usual qualities of the product permanently or add new and undesirable characteristics. In either case, the contaminated product may be unsuitable for its intended use. Contamination may result from accident, inability or neglect or follow prescribed procedures, gross carelessness, or sabotage. In most instances contamination of a product can be detected by its unusual appearance, color, gravity, or odor.

Dirt

The causes for the presence of sand, clay, or loam in appreciable quantity in petroleum products should be investigated at once and remedial action taken. It may be the result of carelessness or of sabotage. Most commonly it is the result of inadequate cleaning and inspection of tanks or containers, or the use of muddy water to flush pipelines.

In light fuels such as gasoline, in cans or drums, dirt settles in a few hours. The clear fuel may then be drawn off and the bottom (4 to 10 inches) recovered by filtration through a dry chamois. An alternative is to decant the fuel into larger containers for further settling by pouring off the fuel without disturbing the sediment in the bottom of the container. In bulk tanks the settling may require 12 to 24 hours. The clear fuel may then be run off to clean storage and the bottom layer passed through gasoline filters, if available, or downgraded. Tanks and other containers should be thoroughly cleaned before reusing. In heavier fuels such as diesel oils or JP-5 jet fuel, settling is much less satisfactory. Filtration is recommended if practicable. Otherwise it is usually necessary to downgrade the product. In the case of lube oils and greases, no remedial action can be taken. The product must be downgraded.

Rust

Rust is the common name for the product of corrosion which is formed when unprotected iron or some steel surfaces are subjected to prolonged contact with water or moist air. It is brittle and powders readily. It is insoluble in water and in petroleum products but may form troublesome suspensions because of turbulent flow in pipelines, the churning action produced while pumping into storage tanks, or the rough

Table 3-1.—Military and Commerical Designation for Gear and Lubricating Oils Used in Equipment Maintenance

General Description	Military Designation and Specification Number	Typical Commercial Designation	Uses
Gear oil. . . . . Containing extreme pressure (EP) additives to maintain lubrication under extreme pressure conditions.	Lubricant, Gear, Universal, MIL-L-10324. FSN 9150-259-5443.	E.P. Hypoid Gear Lubricant. Universal Gear Lubricant for very cold climates.	For all gear lubrication including transmission, differentials, hypoid gears, tractor final drives, and steering gear mechanisms in cold climates when the prevailing temperature is below 0° F.
Gear oil. . . . . Containing extreme pressure (EP) additives to maintain lubrication under extreme pressure conditions.	Lubricant, Gear, Universal, MIL-L-2105. FSN 9150-577-5842.	SAE 80 EP Hypoid or Universal Gear Lubricant. MA 1327	As above except that it is an SAE 80 gear lubricant for use where the prevailing temperature is between 0° and 32° F.
	FSN 9150-577-5845.	SAE 90 EP Hypoid or Universal Gear Lubricant. MA 1328	As above except that it is an SAE 90 gear lubricant for use where the prevailing temperature is above 0° F.
Mineral Gear Oil, SAE 140. NO ADDITIVES.	Military Symbol 5190. MIL-L-2105. FSN 9150-577-5848.	SAE 140 Mineral Gear Oil. Steam Cylinder Oil. MA 1329	For use in tractor transmissions and final drives only in tropical areas. There are no extreme pressure chemical additives in this oil. DO NOT mix with extreme pressure lubricants. DO NOT use in hypoid gear drives such as truck or passenger vehicle differentials.
SAE-10 Heavy Duty Lubricating Oil.	Military Symbol 9110. FSN 9150-231-9039.	Gasoline and Diesel Engine Oil, SAE-10 and SAE-10W Grades.	For crankcase lubrication in both gasoline and diesel engines requiring an SAE-10 or SAE-10W oil and for general purpose lubrication.
SAE-20 Heavy Duty Lubricating Oil.	Military Symbol 9170. FSN 9150-231-6651.	Gasoline and Diesel Engine Oil, SAE-20 Grade.	For crankcase lubrication in both gasoline and diesel engines requiring an SAE-20 oil and for general purpose lubrication.
SAE-30 Heavy Duty Lubricating Oil.	Military Symbol 9250. FSN 9150-231-6655.	Gasoline and Diesel Engine Oil, SAE-30 Grade. MB 1702	For crankcase lubrication in both gasoline and diesel engines requiring an SAE-30 oil and for general purpose lubrication.
SAE-40 Heavy Duty Lubricating Oil.	Military Symbol 9370. FSN 9150-912-9552.	Gasoline and Diesel Engine Oil, SAE-40 Grade.	For crankcase lubrication in both gasoline and diesel engines requiring an SAE-40 oil and for general purpose lubrication.

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Table 3-1.—Military and Commerical Designation for Gear and Lubricating Oils Used in Equipment Maintenance—Continued

General Description	Military Designation and Specification Number	Typical Commercial Designation	Uses
SAE-50 Heavy Duty Lubricating Oil.	Military Symbol 9500. FSN 1950-231-9043.	Gasoline and Diesel Engine Oil, SAE-50 Grade. MB 1722	For crankcase lubrication in both gasoline and diesel engines requiring an SAE-50 oil and for general purpose lubrication.
Medium VI Mineral Oil SAE-50. No additives.	Military Symbol 3100. FSN 9150-223-8893.	Mineral Oil SAE-50	For lubrication of certain 2-stroke cycle gasoline engines where prescribed. Mixed with fuel in specified proportions such as outboard motorboat engines. For general purpose lubrication.
Hydraulic Transmission Fluid, Type C-1	EO—Series 3 or MIL-L-45199A. Grade 10. FSN 9150-680-1103.	Lubricating Oil High Output.	For hydraulic systems and certain transmission and converter units as prescribed by the manufacturer.

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handling of small containers. Rust is a commonly occurring source of contamination when disused pipelines or containers are employed without proper cleaning. Its prevention in small containers—where it is most likely to occur—is best accomplished by thorough cleaning and subsequent rinsing of the container with a prescribed rust-preventive type oil or solution which will cling to the metal surface in a thin layer and provide temporary protection until the container can be filled with the product to be stored. While empty, the containers should be stored upside down. Active pipelines and large storage facilities do not normally permit the accumulation of rust in appreciable quantity. Rust may be removed from gasoline and heavier fuels by the same methods employed in removing dirt from these products.

Mill-Scale

Mill-scale is a magnetic product formed on iron and some steel surfaces during the manufacturing process. It is largely responsible for the blue-black appearance of such surfaces. It has been observed as a very serious contaminant in bulk products pumped through new pipes during the first few days or weeks of use. The scale is brittle and cracks readily. Corrosion begins at these cracks and proceeds to spread under the scale causing it to flake off. The scale is then carried along by the oil flow and is broken up still further before it reaches terminal storage. Here it may remain suspended for days. Settling is not, therefore, a satisfactory method of elimination. The scale is not removed completely by segregators and consequently, screens are quickly choked. Filtering of such stocks is recommended.

Water

In bulk storage, water can very often be a reason for fuel contamination. Water is sometimes employed as a bottom, to a depth of a few inches, to underlie light products such as gasolines and jet fuels. However, the use of water bottoms should be avoided if at all possible, and only employed when authorized by proper technical authority. It is sometimes used to separate and prevent mixing of products when two products, such as motor gasoline and

Table 3-2.—Military and Commerical Designations for Greases Used in Equipment Maintenance

General Description	Military Designation and Specification Number	Typical Commercial Designation	Uses
Grease, Chasis—Lime, soda or aluminum soap base grease.	Lubricant, General Mil-G-10924 Mil Sym GAA FSN 9150-530-7369	Chassis Grease, Cup Grease, Pressure Gun Grease, No. 1—Soft.	For general use as a pressure gun lubricant, particularly chassis, universal joints, track rollers, ball bearings operating below 150° F. Lime and aluminum soap base grease types are water resistant.
Grease, Wheel Bearing Soda or mixed soap base grease.	Lubricant, General Purpose, No. 2 (Wheel-Bearing-Chassis Lubricant—WB). VV-G-632 Type B, Grade 2. FSN 9150-531-6971.	Wheel Bearing Grease, No. 2—Medium.	For wheel bearings, ball bearings, and as a pressure gun lubricant when operating temperatures are expected to be above 150° F. DO NOT USE TO GREASE UNIVERSAL JOINTS OR OTHER PARTS HAVING NEEDLE BEARINGS. Not water resistant.
Grease, Ball and Roller Bearing Soda or mixed soap base grease.	Lubricant, Ball and Roller Bearing. Mil-G-18709. FSN 9150-249-0908.	Ball and Roller Bearing Grease, BRB.	BRB and G-18709 suitable for ball and roller bearing lubrication, especially in electric motors and generators and clutch pilot bearings. Not water resistant.
Grease—Water Pump Lime soap base grease.	Lubricant, Water-Pump, No. 4. VV-G-632 Type A, Grade 4. FSN 9150-235-5504.	Water-Pump Grease, No. 4—Hard.	For gland type water-pumps of some engines not equipped with factory lubricated and sealed water pumps. Very water resistant.
Lubricant, Exposed Gear, Chain, and Wire Rope Sticky, viscous, black, residual oil.	Lubricant, Chain and Wire Rope. Mil-G-18458. FSN 9150-530-6814.	Exposed Gear Chain and Wire Rope Lubricant. Gear Grease, Wire Rope Grease No. 2.	For greasing cable, open gears or any open mechanism requiring rough lubrication. Usually heated before applying. Grade B is intended for use in temperate or warm weather and is suitable for open-air or under-water conditions. Not for cables in contact with earth.
		As above, except that it is No. 3 or heavy duty type.	As above except that Grade C is for use in hot weather or for hard service and is suitable for open-air or under-water conditions.

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aviation gasoline, are to be pumped through a pipeline, one after the other. Again, this should be avoided if possible as there are better means for segregation of products. The legitimate and necessary uses of water provide ample opportunities for the contamination of light products unless they are controlled by strict adherence to standard operating procedures. Fortunately, water suspended in light products such as gasoline separates rapidly on standing; less rapidly in diesel oil and JP-5 jet fuel. In cold weather this settling may be delayed by the formation of ice crystals, which are lighter than water droplets. In suspension, these crystals may clog filters, fuel lines, or jets in equipment. The most effective precaution against water contamination is to ensure delivery of a well-settled product through a dry line into a dry container. In cold weather, even a small amount of water can cause the freezing of bottom outlet valves in rail tank cars and tank trucks. In the case of packaged products, water may become a contaminant through the use of open or damaged containers, through improper storage and handling methods, and by the breathing which normally occurs in drums and cans. (Breathing is the reverse of vaporization and is caused by a drop in temperature. In breathing, cooled vapors condense to liquids, the interior pressure of the storage tank or container decreases, and air is sucked into the tank or container.)

Water contamination of fuels supplied to consumers in drums or cans can be avoided, when the turnover is rapid, by the application of prescribed methods of inspection, storage, and handling. However, long-term storage in drums, (strategic reserve stocks) cannot fail to result in some contamination. The condensation of some water from the moist air sucked in during the night is inevitable since this water settles and, therefore, is not expelled with product vapors during the heat of the day. During several weeks of storage, this water accumulates in surprisingly large amounts. Not only does it constitute direct contamination, which may have very undesirable consequences if transferred to equipment, but it is the cause of serious additional contamination by rust, and increases container maintenance. For this reason, periodic technical inspection is required and provision must be made for the regular replacement of such stocks at relatively frequent intervals. The length of intervals is determined by climatic and other conditions. Accumulated water can best be removed by decantation, settling, and refilling. Lacking time or facilities for this, a small pump may be employed to remove the lower layers from individual containers.

The most effective and proper protection for lubricants is to keep them well covered, preferably in inside storage. Should damaged containers permit water to contaminate engine or gear oils, the water may remove some of the essential additives. Even more undesirable is the fact that water tends to emulsify in the oil and does not settle out, thus decreasing effective lubricating action. Water can be poured off from greases. When this is done, about an inch of surface grease should also be removed. After removal, the surface grease should be burned or buried.

Commingling of Products

Commingling of products may result from inadequate cleansing of lines or containers; from the use of unmarked or improperly marked containers; and from the mishandling of manifolds. In such cases it can be minimized by supervision sufficient to ensure strict application of the prescribed petroleum handling procedures. Commingling may also result from leaks in tanks or valves aboard tankers, and from leaky valves or insufficient protective facilities in shore installations. These sources can be minimized by proper inspection and maintenance procedures. Nevertheless, serious contamination of one product by another can and does occur occasionally in field operations. This is one of the most compelling reasons for the continuous inspection procedures and the routine testing programs prescribed by the military departments.

Commingling can be negligible or serious depending upon the product contaminated, the contaminating agent, and the amount of contamination. Some of the more important serious effects are:

1. Loss of power in fuels.
2. Increase in volatility (producing a fire or explosion hazard in kerosene or diesel fuels).
3. Increase in gum content.
4. Formation of heavy sludge.

SAFETY IN HANDLING AND STORAGE OF PETROLEUM PRODUCTS

Although the handling of petroleum products presents many hazards, both bulk and packaged products can be handled safely and with remarkable freedom from accident if proper precautionary measures are taken. All personnel involved with the receipt, storage, issue, and use of flammable and combustible petroleum products must be familiar with and observe applicable safety precautions.

Precautionary measures must be taken to prevent fire and explosion when handling any petroleum product. The degree of hazard involved depends on the properties of a given product. Therefore, for safe handling purposes, petroleum products are divided into groups or classes according to the temperature at which the product will give off flammable vapors.

Any material which can be ignited easily and which will burn with unusual rapidity is said to be flammable. (The terms flammable and inflammable are identical in meaning, but the former is preferred since the prefix in suggests non flammable.)

All petroleum products, being composed of carbon and hydrogen, will burn and are therefore combustible materials. However, classification for safe handling purposes distinguishes products according to their tendency to burn.

Combustible liquids, according to the National Fire Protection Association (NFPA) Standards, are those liquids having flash points at or above 140°F and below 200°F.

Flammable liquids, according to the NFPA Standards, include all liquid petroleum fuels which give off flammable vapors below temperatures of 140°F.

Volatile products are products which tend to vaporize; that is, give off flammable vapors at comparatively low temperatures are said to be volatile. Because volatile products such as gasoline and JP-4 jet fuels will give off sufficient vapors to be flammable at relatively low temperatures, they are the most hazardous of all petroleum products to handle. For example, gasoline has a flash point of about -45° and JP-4 jet fuel has a flash point slightly higher, while crude oil has a flash point of about 60°F. This varies, however, according to the source of the crude oil. Volatile products such as gasoline and JP-4 jet fuel are normally handled at atmospheric temperatures above -45°F and, therefore, give off sufficient vapors to flash or burn at all times. Products which give off flammable vapors only above 100°F and are relatively nonvolatile are relatively safe to handle at ordinary temperatures and pressures. Such petroleum products as kerosene, JP-5 jet fuel, diesel and light and heavy fuel oils are included in this category.

It is noted, however, that if products such as kerosene, JP-5 jet fuel, diesels and fuel oils are handled at elevated temperatures they are just as hazardous as the volatile products. For example, kerosene, which has a flash point of about 110°F will not ignite at ordinary atmospheric temperatures, but if it is heated above 100°F will give off sufficient flammable vapors to burn or explode. All products which have a flash point above 100°F when heated to temperatures equal to or higher than their flash point, should be treated as volatile products with respect to fire and explosion hazards.

Some precautionary measures to be strictly observed when handling petroleum products are listed below. Most of these precautions apply to the handling of any flammable or volatile product at ordinary temperature, and higher flash or less volatile products at high temperature.

1. Reducing Or Controlling The Discharge Of Vapors
   a. Take care that no spills occur.
   b. Avoid spills from overflow when loading storage tanks by gaging tanks prior to loading.
   c. Never neglect leaks. Make frequent inspections for leaks in tank seams, tank shells, and pipe joints.
   d. If spills or leaks occur, clean them up immediately. Soaked ground should be washed with water or covered with sand or dry earth. The area should be policed until flammable vapor has been eliminated.
   e. When temperatures are excessively high, cool storage tanks by sprinkling, or by playing water over them.
   f. Keep containers for volatile products, whether empty or full, closed tightly.
   g. Beware of empty fuel containers.
   h. Ensure proper ventilation of all enclosed spaces in which vapors may accumulate.

2. Eliminating Sources Of Accidental Ignition
   a. Do not smoke.
   b. Do not carry "strike anywhere" matches or automatic lighters that open and light with a single motion.

c. Do not perform any mechanical work or repair involving hot work such as burning, cutting, or welding, unless a permit is issued by proper authority.

d. Inspect electrical apparatus frequently and correct any condition likely to cause sparking.

e. Open switches and pull fuses before work is done on electrical equipment.

f. Shut off gasoline tank truck engines during the entire period of filling or discharging unless the truck is designed for engine operation, to drive transfer pumps through a power take-off.

g. Ground flammable fuel hose nozzle to the tank before starting the flow of fuel. Maintain this bond throughout the filling operation.

h. Never load or unload volatile or flammable products during electrical storms.

i. Use only self-closing metal receptacles for discarding oily waste or rags and dispose of such collections daily.

j. Never use volatile petroleum products such as gasoline for any cleaning purpose.

k. Keep gage tape in contact with gage hatch during gaging operations.

l. Immediately remove any clothing which has become soaked with fuels.

3. Safety Precautions For Handling JP-4 Fuel:

In addition to the safety precautions required for handling all volatile fuels, Grade JP-4 fuel, because of its tendency to accumulate and discharge static electricity and its low vapor pressure, requires additional handling precautions. Like other volatile fuels, JP-4 still requires a source of ignition. Unlike the other volatile fuels, the static electricity generated in pumping, transferring and loading JP-4 is an inherrent source of ignition, which requires careful handling to control. JP-4 fuel is unique in that its rate of vaporization under most handling conditions will create an atmosphere (vapor/air) well within the explosive range, within the tank above the liquid surface. The atmosphere within a fixed roof tank storing gasoline will normally be too rich to be ignited or to burn within the tank, but in the case of JP-4, any ignition at gaging hatches, or vents will travel into the tank and cause a violent combustion (explosion). This hazard is not normally present in the case of Grade JP-5 fuel because of its relatively high flash point (140°F). To minimize the generation and a accumulation of static electric charge in JP-4 fuel, the following procedures and/or precautions are recommended:

a. Do not use overhead fill lines which permit a free fall of product through the air.

b. The entrance of air into fill lines should be minimized or eliminated if practicable.

c. Where feasible the storage of JP-4 in concrete tanks or other poor electrical conducting materials should be avoided.

When handling petroleum products, care must be taken to ensure they do not become contaminated with foreign matter. Since all petroleum products will burn, fire is an ever present hazard. The degree of fire hazard increases as the volatility of the product increases.

Inhaling gasoline vapors may cause headaches, dizziness, nausea, or even unconsciousness. If any of these symptoms are noticed among men handling gasoline or working in an area where gasoline has been spilled, the men should leave the area at once. If anyone has been overcome, he should receive immediate medical attention.

Gasoline may cause severe burns if allowed to remain in contact with the skin, particularly under soaked clothing or gloves. Clothing or shoes through which gasoline has soaked should be removed at once. Gasoline should be washed from the skin with soap and water. Repeated contact with gasoline removes the protective oils from the skin and causes drying, roughening, chapping, and cracking and, in some cases, infections of the skin. Rubber gloves should be worn as protection by persons handling petroleum products.

If gasoline gets into a person's eyes, first aid should be given immediately. Fresh water may be applied, and medical attention should be secured.

If a person swallows gasoline by accident, first aid should be given immediately. Giving the victim warm salty water to induce vomiting is an effective aid. Medical attention should be secured promptly.

Slipping and falling are common accidents which occur when handling petroleum products. This danger is particularly grave while climbing to and from loading racks, storage tanks, or stacks of drums or cans. Tools, pieces of lumber, and other objects should not be left lying where they may cause accidents.

On a hot day, gasoline vapors mixed with air may be flammable for a distance of 20 feet from an open container. By using underground tanks there will be less chance of a fire or an explosion, and less gas will be lost by evaporation. Areas near gasoline storage tanks should ALWAYS BE WELL POSTED WITH WARNING SIGNS.

Gasoline storage tanks should be placed underground and covered with at least 3 or 4 feet of earth. The tanks must be equipped with vent pipes which extend well above the ground (6 to 8 feet) so that the vapors may spread and disappear. (See fig. 3-11.)

Diesel fuel is not as volatile, flammable, nor as dangerous to handle as gasoline. But it will burn, and in closed unventilated places, diesel vapors can be explosive.

Diesel fuel is generally not stored in the same way as gasoline. Figure 3-12 shows a typical diesel fuel storage tank. The tank is generally placed above ground on a raised platform. The platform should be high enough to permit the fueling of equipment from the tank by gravity flow. The tank must be provided with an air vent at the top and a drain cock at the lowest point. The outlet for the fuel should be at least 6 inches from the bottom of the tank, so that any water and dirt which have accumulated and settled in the bottom will not be drained into the fuel tanks of the equipment being serviced. The water and sediment that collect in the bottom of the tanks should be drained off daily. When you fill a diesel fuel storage tank, remember to leave enough room for expansion of the fuel. Lubricating oil and greases are furnished in various sizes of containers. More lubricant is wasted because it has become contaminated than for any other cause. All containers should be clearly marked as to their contents and dates received. The lubricants that have been in stock the longest should be used first. Make sure that all openings of lubricant containers are properly secured. This will decrease the chances of lubricants becoming contaminated.

FILTERS

In discussing diesel fuel, it was emphasized that it must be clean for proper diesel engine operation. So important is clean fuel, that besides the precautions observed in handling and storing diesel fuel, manufacturers have built fuel strainers and filters into the fuel systems or diesel engines.

FUEL OIL FILTERS

In addition to a metal strainer, most diesel-fuel systems also contain a filter to remove any remaining small particles of dirt that might clog the injectors. Fuel-oil filters are manufactured in various models by a number of manufacturers. All fuel entering the injectors first passes through the filter elements. The filter elements are made of cotton fiber or mineral wool and glass cloth. After continued use, these filters will become packed with dirt filtered from the fuel, and the flow of fuel to the engine will be reduced to a point where the engine ceases to function properly or stops. Most types of heavy equipment have fuel pressure gages which will indicate when filters are dirty. Filter elements are easily removed and should be replaced with new elements when they start to restrict the flow of fuel to the engine.

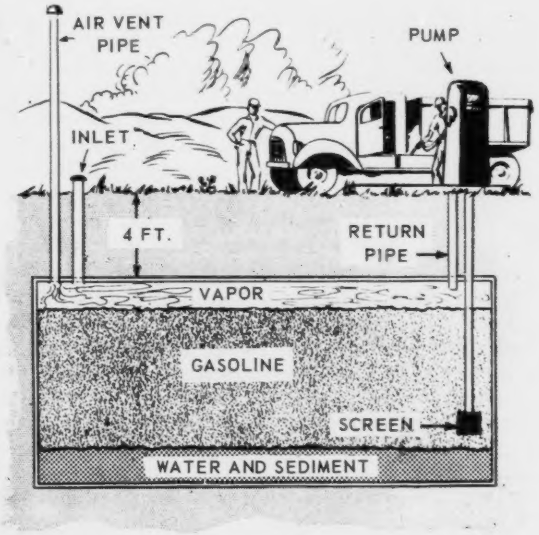

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Figure 3-11.— Underground gasoline storage tank.

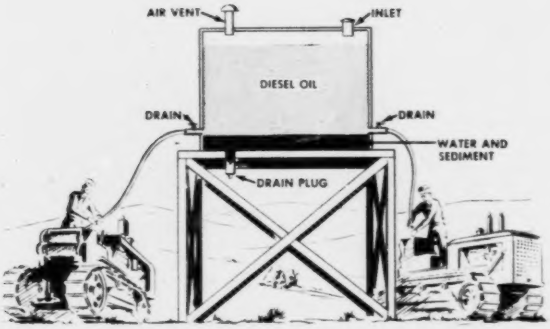

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Figure 3-12.—Storage tank for diesel fuel.

LUBRICATING OIL FILTERS

Most internal combustion engines are equipped with an oil filter. This device filters out the dust, dirt, and grit that enter the oil during operation of the engine.

Construction equipment lubricating oil filters (fig. 3-13) contain a filtering element for their filtering action. When this filtering element is saturated with solid particles, it ceases to function. It is good practice to replace the element with a new one every time the crankcase is drained and new oil is added. By such replacement you are assured of clean oil and a minimum of wear on engine parts.

The three types of oil filter systems used on automotive engines are the bypass, full-flow, and shunt types. The bypass type of oil filter is bracket mounted to the cylinder head or manifolds with connecting oil lines to the engine. The oil from the oil pump passes through the oil filter and then to the crankcase in the bypass system. The full-flow type of oil filter is integral with the engine. The oil is directed under pressure through the filter and then to the engine bearings. When the oil is too cold to circulate through the filter in the full-flow system, a bypass valve directs the oil around the filter element. The shunt type filters only a portion of the oil at a time, as does the bypass system, but the oil which is filtered is passed directly to the engine bearings.

Bypass systems use three types of filters. They are the throw-away type (fig. 3-14), the screw-on type of throw-away filter (fig. 3-15), and the replaceable element type of filter (fig. 3-16). The full-flow and shunt systems use the replaceable element type of the screw-on type of throw-away filter. A replaceable element for a full-flow type filter is shown in figure 3-17.

The throw-away type of oil filter is replaced as a complete unit. You have to disconnect the oil line fittings at the filter. Detach the filter from its bracket and remove the brass fitting from its filter housing. Throw away the filter. Place a bolt or plug into the brass fitting when you are removing or installing it. Brass is malleable (easily bent) and may be crushed by excessive wrench pressure.

The screw-on, throw-away type filter is also replaced as a complete unit. You unscrew

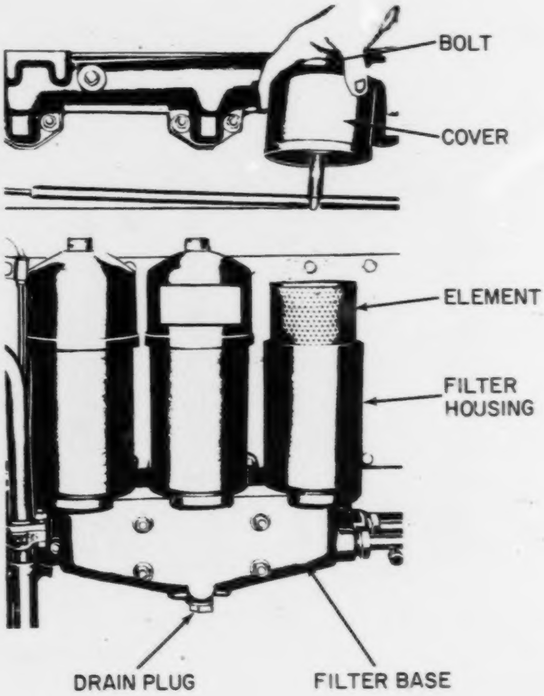

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Figure 3-13.—Lubricating oil filter for construction equipment.

the filter from the base by hand and throw the filter away. Wipe the base clean with a cloth and screw a new filter onto the base by hand, tightening at least half a turn after the gasket contacts the base. Fill the crankcase to the full mark on the dipstick with the proper grade and weight of oil. Start the engine and observe the oil pressure and check for leaks around the oil filter. Stop the engine and add oil to the full level if needed.

To service replaceable element oil filters, you remove the fastening bolt, lift off the cover or remove the filter shell. Remove the gasket and throw it away. When removing the oil filter of the full-flow or shunt type, place a pan under the filter to catch the oil. Take out the old element and throw it away. Throw away the gasket from the top and bottom of the center tube if they are present. Place a pan under the filter and remove the drain plug if the filter is used in the bypass system. Clean the inside of the filter shell and cover. Install metal supports and a new bottom tube gasket. Insert a new element and a new top tube gasket. Insert a new cover or housing gasket (make sure that the gasket is completely seated in the recess). Replace the cover or housing and fasten the center bolt securely. Fill the crankcase to the full mark on the dip stick with the proper grade

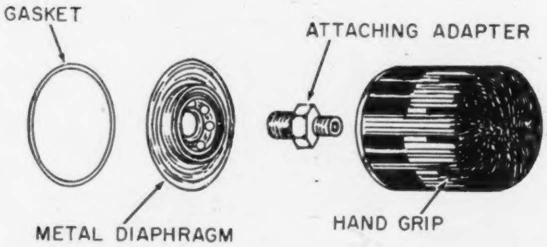

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Figure 3-15.—Screw-on type of throw-away oil filter.

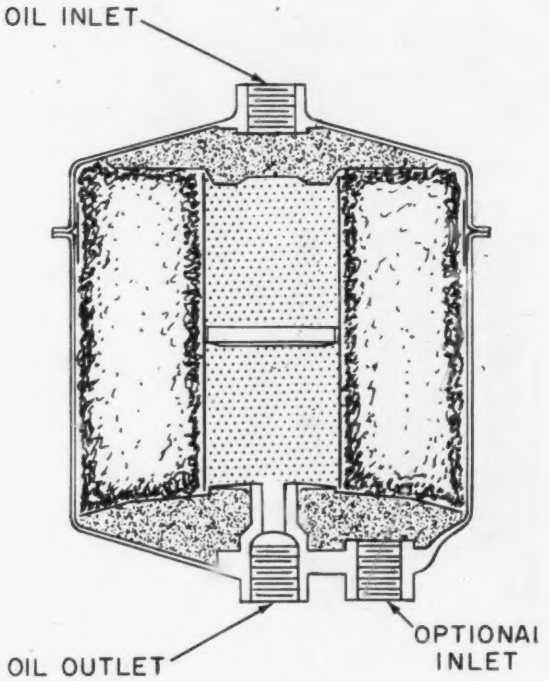

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Figure 3-14.—Sealed type of throw-away oil filter.

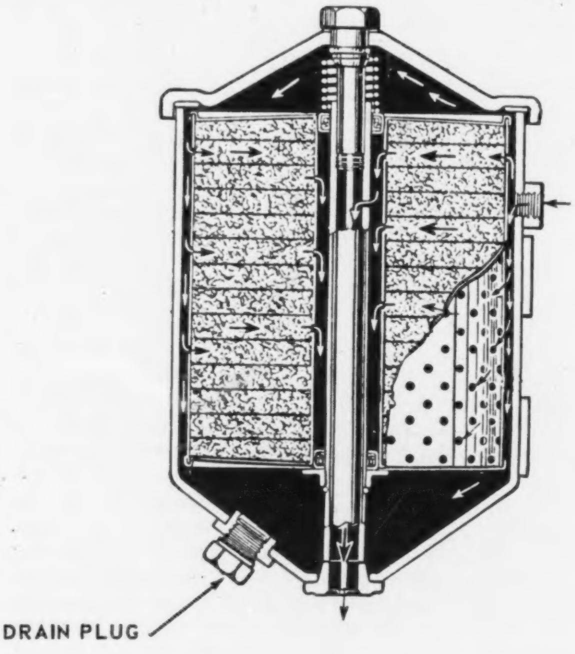

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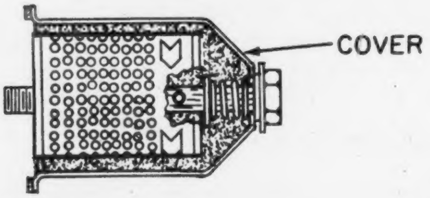
Figure 3-16.—Replaceable element type oil filter.



81.329
Figure 3-17.—Replaceable element, full-flow type oil filter.

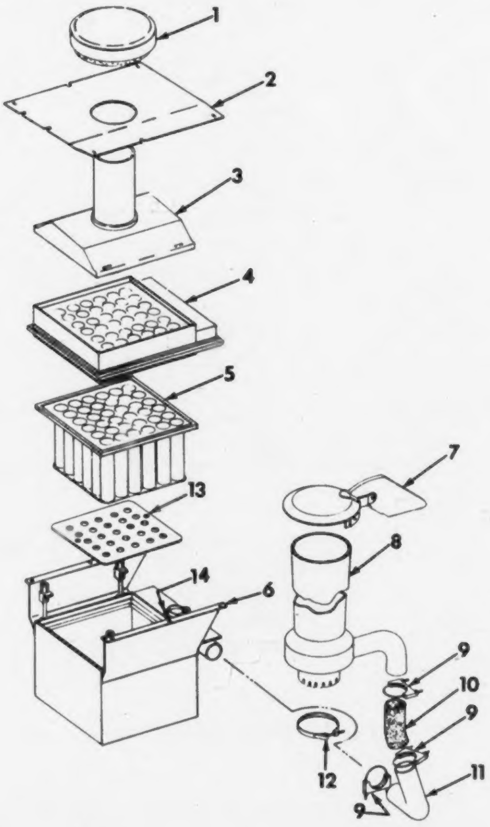
and weight of oil. Start and idle the engine. Check the oil pressure immediately and inspect the filter for oil leaks. Then stop the engine and check the crankcase oil level and add oil to the full mark. The final step in the procedure is to mark the mileage on the sticker so that the element of the oil filter will be replaced at the proper interval.

DRY-TYPE AIR CLEANERS

The heavy duty dry-type air cleaner illustrated in figure 3-18 uses a replaceable element. Air enters the cleaner through the air intake cap and screen (1) which prevents chaff and coarse dirt from getting into the air cleaner. After passing through the adapter (3) and rotonamic panel (4), the air is filtered as it passes through the replaceable dry-type element (5) and filter housing (6). The filtered air is then drawn into the engine through the intake manifold.

OIL-BATH AIR CLEANER

The oil-bath air cleaner shown in figure 3-19 consists of main body, air intake cap, screens, and oil reservior. Air enters the intake cap and inlet screen (1) which prevent large particles such as dirt, chaff, leaves, and so forth, from entering the air cleaner. After passing down the inlet pipe (2) to the center oil reservior (3), the air is deflected upward through the screen (4), carrying drops of oil. The oil absorbs dirt from the air as it passes through the screen. The screen is sloped so the air sweeps the dirt laden oil toward the outside of the cleaner where it falls and re-enters the oil reservior. The clean filtered air is then drawn into the engine through the intake manifold pipe (5).

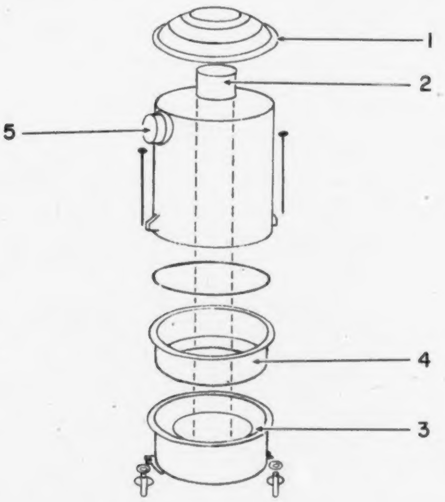


1. CAP, air intake.
2. PANEL, removeable.
3. ADAPTER, intake.
4. PANEL, rotonamic.
5. ELEMENT, filter.
6. HOUSING, air cleaner.
7. CAP, weather.
8. ASPIRATOR.
9. CLAMP.
10. HOSE.
11. ELBOW, exhaust.
12. CLAMP, aspirator.
13. PLATE, support.
14. GASKET.

81.97
Figure 3-18.—Heavy duty dry-type air cleaner.

ENVIRONMENTAL POLLUTION CONTROL

Environmental pollution is that condition which results from the presence of chemical, physical or biological agents in the air, water or soil



1. Intake cup and inlet screen.
2. Inlet pipe.
3. Center oil reservoir.
4. Screen.
5. Intake manifold pipe.

81.96

Figure 3-19.—Oil bath air cleaner.

which alter the natural environment. This causes an adverse effect on human health or comfort, fish and wildlife, other aquatic resources and plant life, and structures and equipment to the extent that economic loss is produced and recreational opportunity is impaired. Pollution causes nylon hose to disintegrate, masonry to crumble, steel to corrode, and skies to darken. It also damages vegetation, causes illness, and results in the loss of countless work days.

AIR POLLUTION

As an EO, you should be aware of the conditions which cause air pollution when operating equipment, and the efforts being made to minimize or correct these conditions.

When incomplete combustion occurs, unburned hydrocarbons and various other constituents in the basic fuel combine chemically to form some visible, noxious, and harmful byproducts which are emitted into the environment. Some of the fuel components and combustion products which have an adverse effect on the air are carbon monoxide, particulate matter, sulfur, oxides, unburned hydrocarbons, nitrogen oxides, and lead.

CONTROLLING AIR POLLUTION

The most effective means of controlling air pollution caused by fuel combustion is to maintain a well-tuned engine that provides an optimium fuel and oxygen mixture and proper timing; this results in most efficient combustion. Another alternative, not always under control of an operator, is to use only the best grade of fuel available which contains low particulate matter, low water and sulfur content, and other contaminates. Automotive manufacturers now provide systems on engine to return "blowby" (unburned fuel) to the carburetor for combustion, i.e., a pollution control system. Long range research and development is underway in developing systems to remove harmful constituents from engine exhausts, e.g., catalytic filter scrubber systems to remove oxides of sulfur and nitrogen, and others to remove lead.

WATER AND GROUND POLLUTION

In addition to creating a fire hazard, oil and other fuel products pose many possible pollution threats when spilled on the water or ground. Oil products on the ground can infiltrate and contaminate ground water supplies or can be carried into surface water supplies with ground runoff due to rain. Oil products carried into storm or sanitary sewers pose potential explosion hazards. Gasoline seeping into a sewer from a service station created an explosion which demolished several city blocks in a Chicago suburb in the late 1940's.

Oil on the water surface blocks the oxygen flow from the atmosphere into the water which results in less oxygen in the water for the fish and other aquatic organisms. Fish can be harmed by eating oil or smaller organisms that have eaten the oil. If the fish do not die from the oil coating their gills or from eating the oil, their flesh is tainted and they are no longer suitable for consumption by man. In addition to harming aquatic organisms and contaminating water supplies, oil products foul boats, water front structures, beaches, and in general create an unsightly mess along the waterfront.

Of all the oil introduced in the world's waters, spent oils from highway vehicles accounted for 37 percent, or 2 million tons in 1969. This is the largest single source of oil pollution, ever greater than tankers (11 percent), other ships (10 percent), offshore oil production (2 percent), refineries and petrochemical plants (6 percent), industrial and all other vehicles (31 percent), and accidental spills (4 percent).

PREVENTIVE MEASURES FOR WATER AND GROUND POLLUTION

During automotive repair, drip pans and an absorbent material should be used to catch all unavoidable spills. Spilled oil or fuels should never be washed down a drain or sewer, unless an immediate fire hazard exists and an oil-water separator is present in the discharge line. Where spills are expected to occur (gasoline fill stands, etc.), absorbent material should be on hand. This material can be sprinkled on spilled oil or fuel, placed in a container, and disposed in a sanitary landfill or other non-polluting manner.

Spent crankcase oil, filters, contaminated fuel should be collected and disposed of in a non-polluting manner. Most naval activities collect and dispose of waste oil periodically through a contractor, by burning in a boiler plant, or reprocessing in an oil reclamation plant. Naval supply fuel farms usually have means to properly dispose of waste oils.

Open vehicle repair or maintenance areas located near water-courses or bodies of water should be landscaped and diked so spilled oil products cannot easily or directly flow into the nearby water.

In addition to preventing oil pollution from vehicle and equipment operation, SEABEES are being considered for use in beach cleanup during major oil spill disasters. The techniques and uses of construction equipment in beach cleanup may be incorporated in training requirements and, in the event of a regional or national disaster from a major oil spill, the new capability can be utilized as required by local Commanders through the SEABEE unit's self-help program or on a national scale. A well trained SEABEE team could form the nucleus and directing force of a large scale beach cleanup exercise employing a large number of men and equipment.

CHAPTER 4

AUTOMOTIVE POWER TRAINS AND CHASSIS

The mechanism that transmits the power of a vehicle's engine to the wheels and accessory equipment is called the power train. In a simple situation, a set of gears or a chain and sprocket could perform this task, but automotive vehicles are not designed for simple operating conditions. They are designed to have pulling power as well as to move at high speeds, to travel in reverse as well as forward, and to operate on rough terrain as well as on smooth roads. To meet these varying demands, a number of units have been added including clutches, transmissions, propeller shafts, universal joints, differentials, and live axles (fig. 4-1).

The chassis is the assembly of mechanisms that make up the major operating part of the vehicle. It usually includes everything except the vehicle body. This assembly includes the engine, the frame which supports the engine and the power train, the steering and braking systems, and the suspension system.

This chapter provides information on the various components, or subassemblies, that make up the automotive power train and chassis. In effect, it establishes the relationship between these various parts and shows how they work together in the automotive vehicle. To maintain and service these components, or subassemblies, you must know where to find them on a vehicle. You must also understnad their purpose and how they operate. This chapter contains a general discussion of these subjects; the operation and maintenance manuals which accompany each piece of equipment will give you more detailed information.

POWER TRAIN COMPONENTS

The common elements of the power train system assembled in a typical vehicle are shown in figure 4-1. The main components of the power train are described as follows:

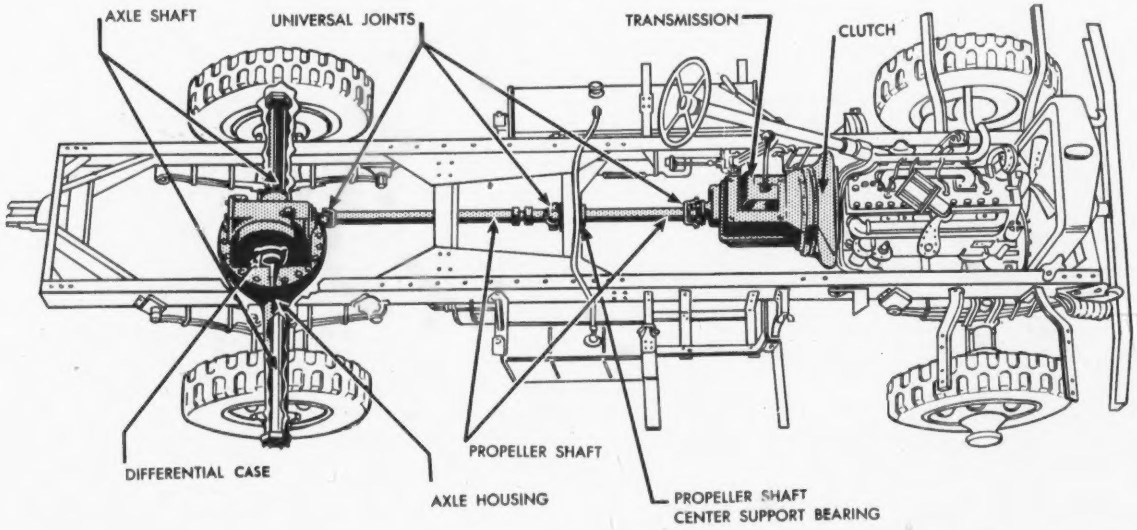
CLUTCH. By means of the clutch, the operator can disconnect the engine from the remainder of the power train. This is essential when starting the engine, thus allowing the vehicle to stand motionless while the engine is running. It also allows gradual engagement of the engine to the power train and gear ratio changing to meet varying road conditions.

TRANSMISSION. An internal combustion engine cannot develop appreciable torque at low speeds; it develops maximum torque only at one speed, and the crankshaft of an engine must always rotate in the same direction. Because of these limitations, a transmission is necessary in automotive vehicles. The transmission provides the mechanical advantage that enables the engine to propel the vehicle under adverse conditions of the load. It also provides the operator with a selection of vehicle speeds while the engine is held at speeds within the effective torque range, and it allows disengaging and reversing the flow of power from the engine to the wheels.

PROPELLER SHAFT. A propeller shaft is used to transfer the power from the transmission located near the front of the vehicle to the differential near the rear.

UNIVERSAL JOINTS. It is necessary to provide flexibility in the power train if springs are to be used on the vehicle. As the load is increased or decreased, and as the vehicle travels over uneven surfaces, the vertical distance between the transmission output shaft and the axle will change. This flexibility is provided by the use of universal joints which permit transfer of torque at an angle.

SLIP JOINTS. As the load is changed, and as the vehicle travels over uneven ground, the distance from the axle to the transmission varies. Slip joints (see fig. 4-11) allow for this variation.



81.174

Figure 4-1.—Typical power train.

DIFFERENTIAL. A differential is required to compensate for the difference in distance the rear wheels travel when the vehicle rounds a turn. The differential permits application of power to the rear wheels while allowing each wheel to turn at a different speed when the vehicle is rounding a curve.

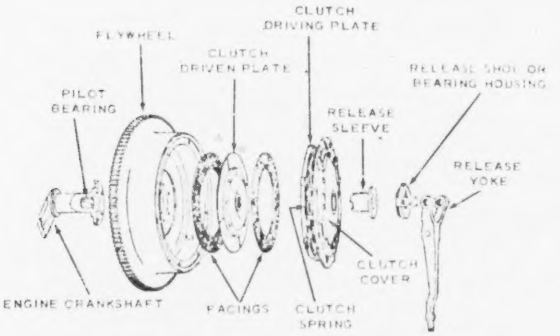
AXLES. An axle is a shaft supporting a vehicle on which the wheels turn. A LIVE AXLE is one that supports part of the weight of a vehicle and also drives the wheels connected to it. A DEAD AXLE is one that carries part of the weight of a vehicle, but does not drive the wheels. The usual front axle of a vehicle is a dead axle and the rear axle is a live axle. In four-wheel drive vehicles, both front and rear axles are live axles, and in six-wheel drive vehicles, all three axles are live axles.

THE CLUTCH

A clutch in an automotive vehicle is the mechanism in the power train that connects the engine crankshaft to, or disconnects it from, the transmission and thus the remainder of the power train. Since the internal combustion engine does not develop a high starting torque, it must be disconnected from the power train and allowed to operate without load until it develops enough torque to overcome the inertia of the vehicle when starting from rest. The application of the engine power to the load must be gradual to provide smooth engagement and to lessen the shock on the driving parts. After engagement, the clutch must transmit all the engine power to the transmission without slipping. Further, it is desirable to disconnect the engine from the power train during the time the gears in the transmission are being shifted from one gear ratio to another.

Clutches are located in the power train between the engine and the transmission assembly, as shown in figure 4-1.

Clutches transmit power from the clutch driving plate to the driven member by friction. In the DISK CLUTCH, figure 4-2, the driving plate or member, which is secured to the engine flywheel, is gradually brought into contact with the driven member (disk), which is attached to the transmission input shaft. The contact is made and held by strong spring pressure controlled by the operator with the clutch pedal. With only light spring pressure, there is little friction between the two members and the clutch is permitted to slip. As the spring pressure increases, friction also increases, and less slippage occurs. When the operator removes his



81.175.2
Figure 4-2.—Exploded and cross-sectional view of a disk clutch.

foot from the clutch pedal and full spring pressure is applied, the speed of the driving plate and driven disk is the same, and all slipping stops. There is then a direct connection between the flywheel and transmission input shaft.

Malfunction Detection

Several types of clutch troubles that may be encountered during vehicle operation are: slipping, chattering or grabbing when engaging; spinning or dragging when engaged; and clutch noises. As an operator, you would explain the malfunction on the Operator's Trouble Report and turn the report into the maintenance shop for corrective action.

Clutch Lubrication

Although some clutches do not require lubrication, there are other types of clutches that require it at periodic intervals. The clutch-pedal control shaft and clutch linkage are among some of the lubricating points that would be greased at normal regular servicing intervals in accordance with the manufacturer's lubrication manual.

MANUAL TRANSMISSIONS

The transmission is part of the power train. It is located in the rear of the engine between the clutch housing and the propeller shaft as shown in figure 4-1. The transmission transfers engine power from the clutch shaft to the propeller shaft, and allows the operator a means of varying the gear ratio between the engine and the rear wheels. Figure 4-3 illustrates a typical manual shift transmission.

The Rate Training Manual, Basic Machines, NAVPERS 10624-A, discusses gears and their mechanical advantages, and explains how to compute the speed and reduction ratio of gears in a typical automotive transmission. If you are a little rusty on this point, study Basic Machines, a manual that will help you to better understand the transmission and power transfer mechanisms described in this chapter.

Dual ratio, or two-speed, rear axles are sometimes used on trucks. They contain two different gear ratios which can be selected at will by the driver, usually by a manual-control lever. A dual-ratio rear axle serves the same purpose as the auxiliary transmission, and like the latter, it doubles the number of gear ratios available for driving the vehicle under the various loads and road conditions.

To eliminate the usual transmission noise developed in the old-type stub-tooth gears used in the sliding gear transmission, manufacturers have developed the CONSTANT-MESH and SYNCHROMESH transmissions. Figure 4-4 illustrates some of the more common forms of gears found in various pieces of automotive and construction equipment.

Operator's Maintenance

It is the operator's responsibility to check with the manufacturer's instruction manual for instruction on the proper type and amount of recommended lubricant to be used in the transmission case. You must maintain the lubricant at the proper level. The normal level of lubricant to be placed in a transmission is usually at the bottom of the filler plug opening. By maintaining the proper level, gear teeth are protected, foaming is reduced, and thus the transmission will continue to perform properly.

Malfunction Detection

Several types of transmission troubles that may be encountered in vehicle operation are: Hard shifting into gears; transmission slips out of FIRST or REVERSE; transmission slips out of SECOND; transmission slips out of HIGH; no power through transmission; transmission noisy in gear; gear clash in shifting; and oil

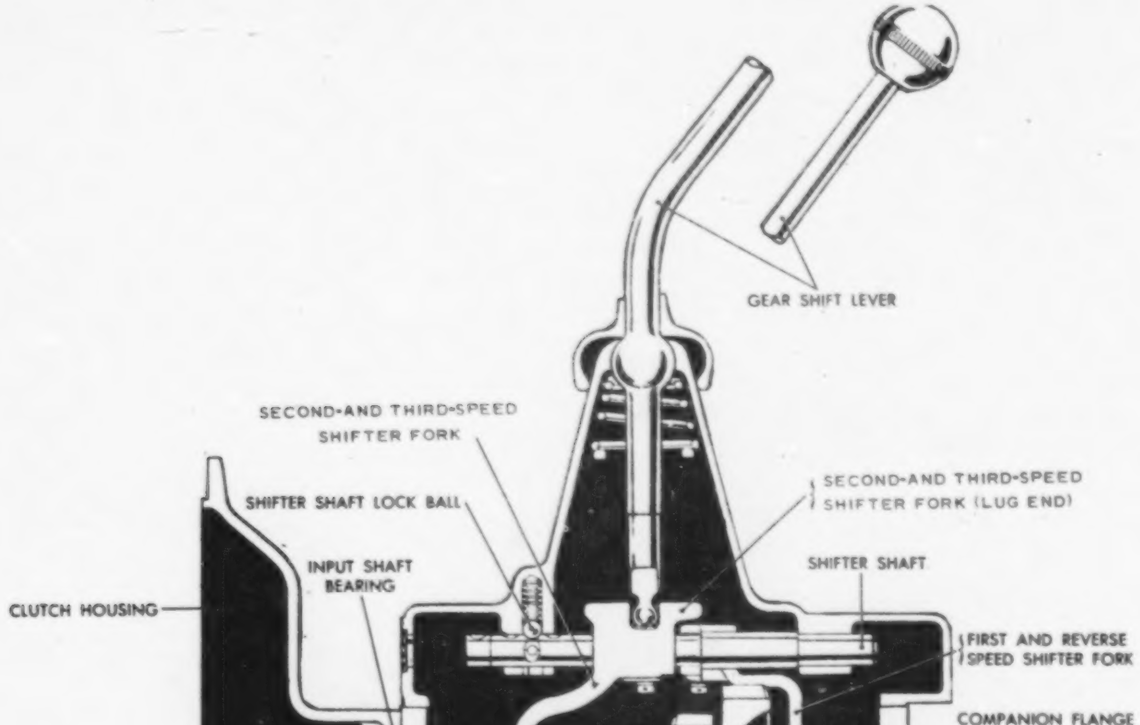
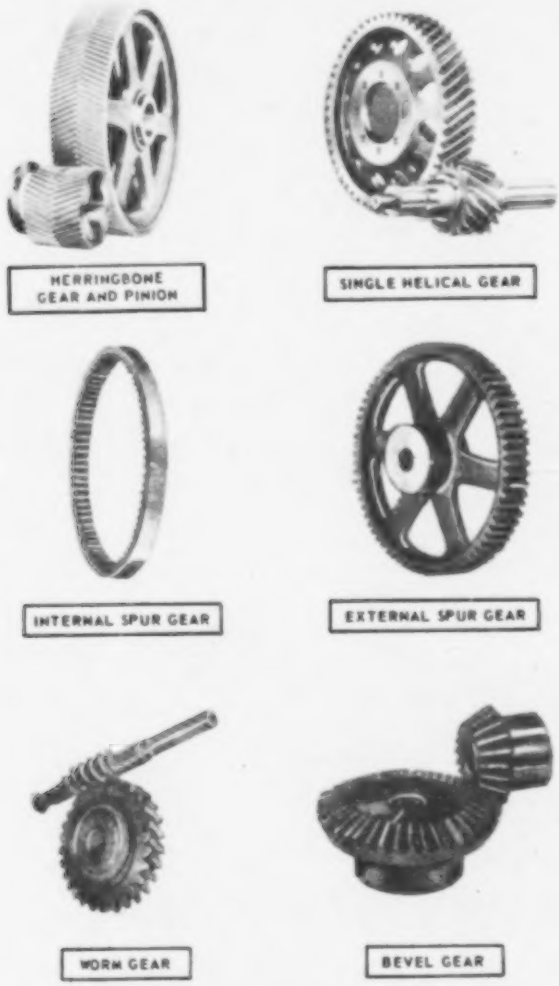


Figure 4-3.—Typical manual shift transmission.



5.22
Figure 4-4.—Types of gears found in automotive and construction equipment.

leaks. As an operator, you would explain the malfunction on the Operator's Trouble Report enabling the mechanic to check out the possible cause of trouble reported.

AUTOMATIC TRANSMISSIONS

The transmissions described previously are manual transmissions; that is, they require a clutch and a lever for shifting gears. The automatic transmission is used in almost all types of automotive and construction equipment. Automatic transmissions are composed of a fluid coupling or hydraulic torque converter and a system of planetary gears controlled automatically.

Fluid Couplings

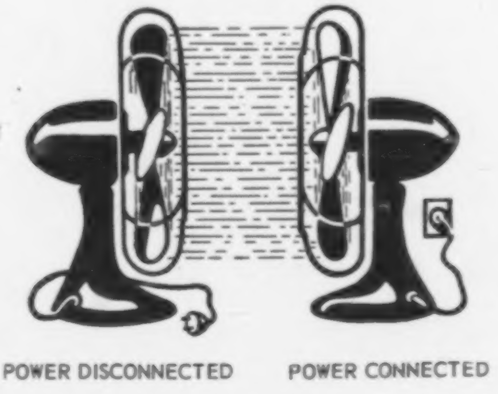
Fluid couplings are widely used with automatic transmissions. By slipping at idling speeds and by holding to increase power as engine speed increases, fluid couplings act as a sort of automatic clutch. There is no mechanical connection between the engine and transmission, but power is transmitted through the use of oil.

The principle of fluid drive can best be illustrated through the use of a pair of electric fans facing each other (fig. 4-5). If one fan is operated with power, the air blast from this fan will cause the other fan to rotate.

There is considerable power loss through slippage at low speeds, but at intermediate or high driving speeds the power loss is very small. It ranges from 1 percent at 25 miles per hour to one quarter percent at 60 miles per hour.

Torque Converters

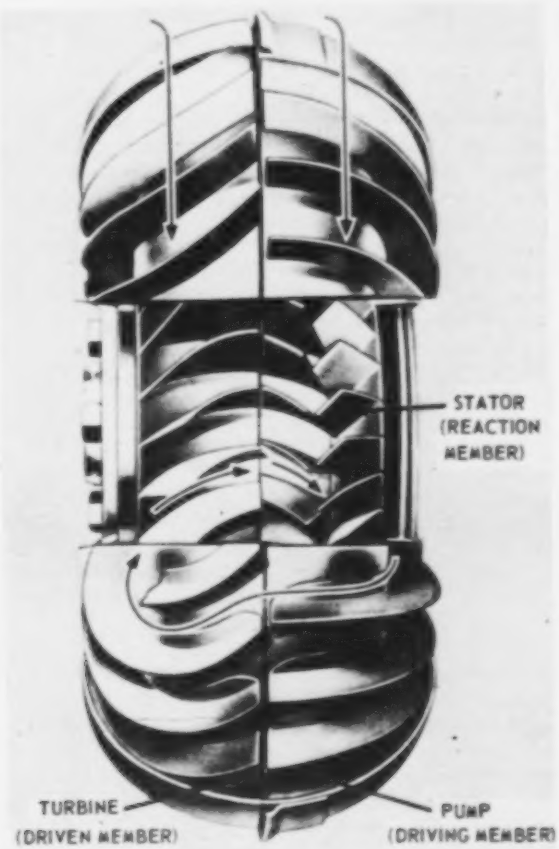
A torque converter is a special form of fluid coupling. It is one of the most common



115.21
Figure 4-5.—Principle of fluid drive.

types of automatic transmissions and is widely used in the latest models of automotive and construction equipment.

The torque converter consists of three basic elements: the pump (driving member), the turbine (driven member), and the stator (reaction member). All of these members have curved vanes. The stator is placed between the load and the power source to act as a fulcrum and is secured to the torque converter housing. Figure 4-6 shows a cutaway view of a torque converter, illustrating the directional flow of oil. The pump throws out oil in the same direction in which the pump is turning. As the oil strikes the turbine blade, it forces the turbine to rotate, and the oil is directed toward the center of the turbine. Then the oil leaves the turbine and moves in a direction opposite to that of the pump. As the oil strikes the stator, it is redirected to flow in the same direction as the pump, thereby adding its force to that of the pump. Torque is multiplied by the velocity and direction given to the oil by the pump, plus the velocity and direction of the oil entering the pump from the stator.



81.210

Figure 4-6.—Cutaway view of torque converter, showing curvature of vanes and direction of oil flow.

Planetary Gears

Automatic transmissions use a system of planetary gears to enable the torque from the torque convertor or fluid coupling to be used as efficiently as possible.

Planetary units are the heart of the modern automatic transmission. An understanding of the power flow through the planetary units is essential to an understanding of the operation of the automatic transmission.

Four basic parts make up the planetary gear system. These basic parts are the sun gear, the ring (or internal) gear, the planet pinions, and the planet carrier. Their relationship is illustrated in figure 4-7.

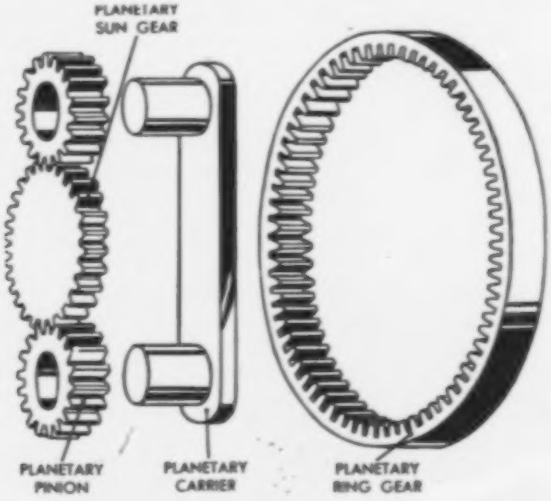


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Figure 4-7.—Members of a simple planetary gear system.

The sun gear is so named because it is the center of the system. The term "planet" is used to describe these pinions and gears because they rotate around the sun gear as shown in figure 4-7. The ring gear, or internal gear, is so called because of its shape and because it has internal teeth.

There are several advantages inherent in the planetary gear system. One of the advantages is the compactness of the system. Another advantage is that there is more tooth contact to carry the load, in that each gear of the planetary system is usually in contact with at least two other gears of the system. (See fig. 4-7.) The gears are always in mesh. There can be no tooth damage due to tooth clash or partial engagement. The big advantage is the one which makes it so popular: namely, the ease of shifting gears. Planetary gear sets in automatic transmissions are shifted without any skill on the part of the driver.

There are various ways in which power may be transmitted through the planetary gear set. A shaft from the engine may be connected to drive the sun gear, it may be connected to drive the planet carrier, or it may be connected to drive the ring gear. The propeller shaft also may be connected to any of these members. However, only power can be transmitted in the planetary gear system when (1) the engine is delivering power to one of the three members, (2) the propeller shaft is connected to one of the other members, and (3) the remaining member is held against rotation. All three conditions must be satisfied for power to be transmitted in the system. Automatic transmissions provide the means for holding a member through hydraulic servos or spring pressure.

Operation

Most automatic transmissions are basically the same. They combine a fluid torque converter with a planetary gear set, and control the shifting of the planetary gears with an automatic hydraulic control system.

The Fordomatic, Merc-O-Matic, Cruise-O-Matic, Powerglide, Hydra-Matic, Torque Flite, and Transmatic truck transmissions, for example, use a combination of fluid torque converter and planetary gears. An understanding of the basic principles of a transmission is a basic understanding of all of them.

To start the engine, the selector lever must be in the Neutral or Park position. It is good practice to apply the service brakes before starting the engine and keep them applied after the engine is running. In the automatic transmission, the fluid torque converter is attached to the engine crankshaft and serves as the engine flywheel. This means that whenever the engine runs, engine power flows into the converter and drives the converter output (turbine) shaft. There is no neutral in the torque converter. Neutral is provided in the planetary gear set by the release of bands and clutches.

With the engine running, you can "feel" the transmission go into gear and into neutral as the selector lever is moved from Park or Neutral to Drive, Low or Reverse. If the engine is running at fast (cold) idle, the vehicle will start to move as soon as the transmission goes into gear, unless the parking or service brakes are applied. If the engine is idling at normal (hot) idle, the vehicle will not move. You can, however, "feel" the transmission go into gear. Part of this "feel" is the audible decrease in engine rpm. The engine is now running under a load. The torque converter and the planetary gear set are actually transmitting engine torque to the driveshaft. The torque applied, however, is not sufficient to move the vehicle.

For all normal forward driving, the selector is moved to Drive. As the throttle is advanced from the idle position, the vehicle will start off smoothly and accelerate steadily. The transmission is designed to operate at a steady-throttle position. Most drivers depress the accelerator pedal to a definite position and hold it there steadily until the desired speed is attained. Depending on the accelerator pedal position, the transmission will upshaft automatically to intermediate and then to high.

The transmission automatically multiplies and/or transmits engine torque to the driveshaft as driving conditions demand. The speeds at which the coupling point and the gear shifts occur are controlled partially by the driver. The driver has only a partial control in the Drive position, because the transmission in the Drive position will shift the planetary gear set into the higher gears to prevent engine overspeeding regardless of throttle position.

The transmission can multiply engine torque as much as 5.4 times. The torque converter can multiply engine torque as much as 2.2 times. The planetary gear set in low gear multiplies the torque converter output torque 2.46 times. The maximum engine torque multiplication in the transmission is 2.2 x 2.46 or 5.41 times. This means that the transmission can receive an engine output torque of 100 ft-lbs and deliver 541 ft-lbs torque to the driveshaft. Of course, frictional losses have to be subtracted from the 541 ft-lbs.

The driver can force downshaft the transmission from high to intermediate at speeds up to about 65 mph. A detent on the downshift linkage warns the driver when the carburetor is wide open. Accelerator pedal depression through the detent will bring in the downshift.

With the throttle closed, the transmission will downshift automatically as the vehicle speed drops to about 10 mph. With the throttle open at any position up to the detent, the downshifts will come in automatically at speeds about 10 mph and in proportion to throttle opening. This prevents engine lugging on steep hill climbing.

When the selector lever is moved to L (low) with the transmission in high, the transmission will downshift to intermediate or to low depending on the road speed. At speeds below about 25 mph, the downshift will be from high to low.

With the selector in Low position, the transmission cannot upshift. On some vehicles the Low position is called Hill Control, since low gear provides maximum engine braking. When maximum engine braking is desired, the transmission must not upshift, because an upshift will reduce engine braking effort. When the selector is moved to Reverse, the hydraulic control system shifts the planetary gear set to reverse. When the selector lever is moved to Park, a spring force is applied against a pawl to engage the parking pawl with a parking gear on the output shaft. When the pawl is engaged, the transmission output shaft (and, therefore the rear wheels) is mechanically locked to the transmission main case.

In summary:

1. An automatic transmission has the torque converter to act as an automatic clutch. This automatic clutch permits the vehicle to stand still at engine idle, but automatically goes to work at a full-throttle start so that the transmission can take maximum engine torque, multiply it more than four times and deliver it to the driveshaft.

2. It is practically impossible to "kill" the engine under any driving condition.

3. At a start, engine speed is fast and vehicle speed is slow. With a steady throttle, engine speed remains fairly constant while vehicle speed increases to 65 mph. You found that the torque converter and planetary gear set "know" when engine torque should be multiplied, how much to multiply it, and when to transmit it to the driveshaft.

4. The ratio changes (shifts) occur at full-engine torque within a fraction of a second and without extreme harshness.

Operator's Maintenance

Periodic service by the operator includes checking the transmission oil level when the engine is idling and at normal operating temperature, the vehicle is level, and the transmission control lever is in park. Remove dipstick and note oil level. If it is low, and sufficient transmission fluid (the oil used in all automatic transmission is special and is composed of mineral oil and additives). In the transmission, it is used as a combination power-transmission medium, hydraulic control fluid, heat transfer medium, bearing surface lubricant, and gear lubricant. In all cases, the manufacturer's recommendations should be followed when servicing and filling the transmission with transmission fluid.

Caution: Do not overfill the transmission because overfilling will cause foaming and shifting troubles.

Malfunction Detection

Several types of automatic transmission troubles that may be encountered during vehicle operation are: No drive in any selected position; engine speed accelerates on standstill starts but vehicle acceleration lags; engine speed accelerates during upshifts; transmission will not upshift; upshift harsh; closed throttle (coast) downshift harsh; will not downshift; vehicle creeps excessively in drive; vehicle creeps in neutral; no drive in reverse, improper shift points; unusual transmission noise; and oil leaks. As an operator, you must explain the malfunction

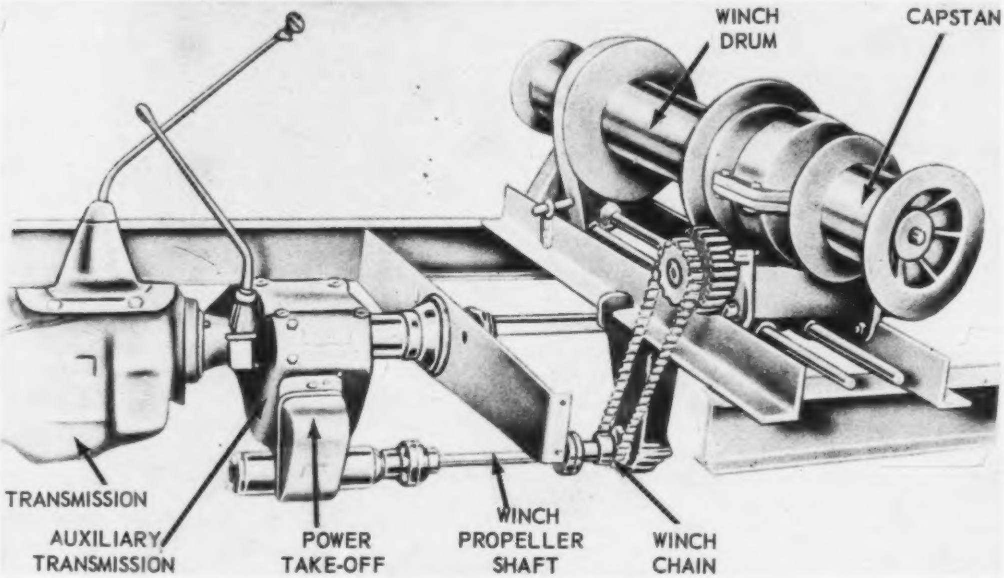

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Figure 4-8.—Auxiliary transmission power take-off driving winch.

on the Operator's Trouble Report and turn the report into the maintenance shop for corrective action.

AUXILIARY TRANSMISSIONS

Auxiliary transmissions are mechanisms mounted in the rear of the regular transmission to provide an increased number of gear ratios. The types most commonly used, normally have only a low and a high (direct) range, incorporated into a transfer assembly. The low range provides an extremely low gear ratio on hard pulls. At all other times the high range is used, and the power passes through the main shaft. Gears are shifted by a separate gearshift lever in the driver's cab. (See fig. 4-8.)

Transfer Cases

Transfer cases are placed in the power trains of vehicles driven by all wheels. Their purpose is to provide the necessary offsets for additional propeller shaft connections to drive the wheels.

Transfer cases in heavier vehicles have two speed positions and a declutching device for disconnecting the front driving wheels. Two speed transfer cases like the one shown in figure 4-9 serve also as auxiliary transmissions.

Some transfer cases are quite complicated. When they have speed changing gears, declutching devices, and attachments for three or more propeller shafts, they are even larger than the main transmission.

Some transfer cases contain an overrunning sprag unit (or units) on the front output shaft. (A sprag unit is a form of overrunning clutch; power can be transmitted through it in one direction but not in the other.) On these transfer cases the transfer is designed to drive the front axle slightly slower than the rear axle. During normal operation, when both front and rear wheels turn at the same speed, only the rear wheels drive the vehicle. However, if the rear wheels should lose traction and begin to slip, they tend to turn faster than the front wheels. As this happens, the sprag unit automatically engages so that the front wheels also

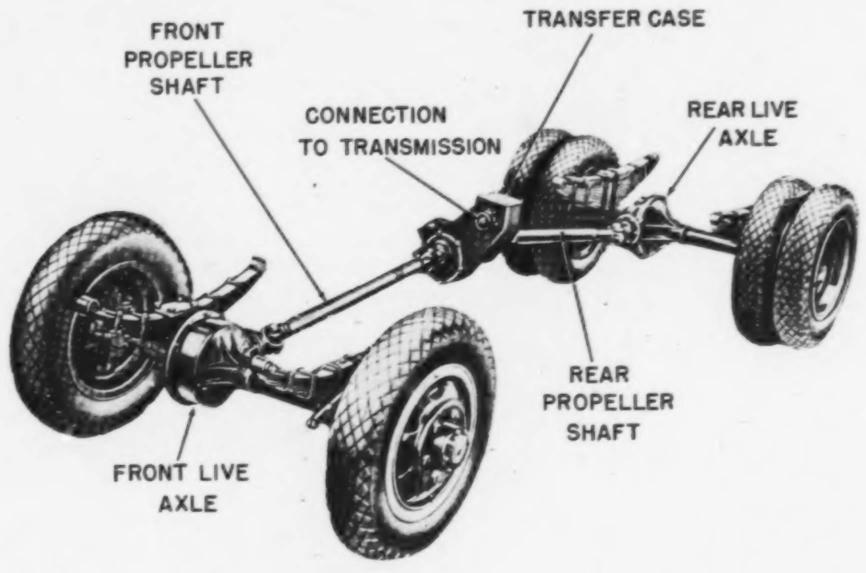


Figure 4-9.—Transfer case installed in a 4-wheel drive truck.

drive the vehicle. The sprag unit simply provides an automatic means of engaging the front wheels in drive whenever additional tractive effort is required. There are two types of sprag-unit-equipped transfers: a single-sprag-unit transfer and a double-sprag-unit transfer. Essentially, both types work in the same manner.

Power Takeoffs

Power takeoffs are attachments in the power train used for obtaining power to drive auxiliary accessories. They are attached to the transmission, auxiliary transmission, or transfer case.

Malfunction detection and operator maintenance for auxiliary transmissions are similar to those for the manual transmission.

PROPELLER SHAFT ASSEMBLY

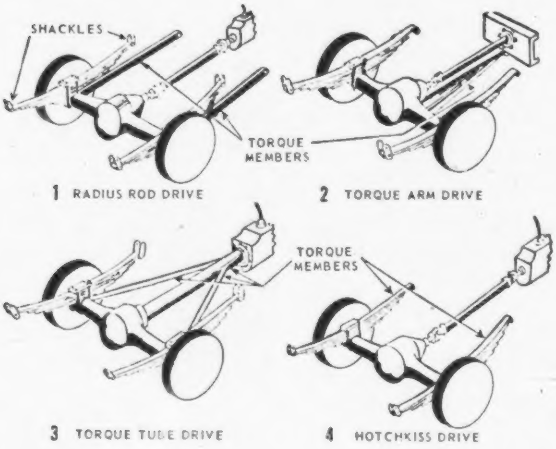
The propeller shaft assembly consists of a propeller shaft, a slip joint, and one or more universal joints. This assembly provides a flexible connection through which power is transmitted from the transmission to the live axles.

The propeller shaft may be solid or tubular. A solid shaft is somewhat stronger than the hollow or tubular shaft of the same diameter, but the hollow shaft is stronger than a solid shaft of the same weight. Hollow shafts are used in the open. (See fig. 4-10).

A slip joint is provided at one end of the propeller shaft to take care of end play. The driving axle, being attached to the springs, is free to move up and down while the transmission is attached to the frame and cannot move. Any upward or downward movement of the axle, as the springs are flexed, shortens or lengthens the distance between the axle assembly and the transmission. To compensate for this changing distance, the slip joint is provided at one end of the propeller shaft.

The usual type of slip joint consists of a splined stub shaft, welded to the propeller shaft, which fits into a splined sleeve in the universal joint. A cross-sectional view of the slip joint and universal joint is shown in figure 4-11.

A universal joint is a connection between two shafts that permits one to drive the other



81.193

Figure 4-10.— Types of drive.

at an angle. Passenger vehicles and trucks usually have universal joints at both ends of the propeller shaft.

Universal joints normally do not require any maintenance other than lubrication. Some universal joints (U-joints) have grease fittings and should be lubricated when the vehicle has a preventive maintenance inspection. Others may require disassembly and lubrication periodically. When lubricating "U" joints that have grease fittings, use a low pressure grease gun to avoid damaging seals.

FINAL DRIVES

A final drive is that part of the power train that transmits the power delivered through the propeller shaft to the drive wheels or to sprockets, in the case of tracklaying equipment. Because it is encased in the rear axle housing, the final drive is usually referred to as a part of the rear axle assembly. It consists of two gears called the ring gear and pinion. These are beveled gears, and they may be spur, spiral, or hypoid as illustrated in figure 4-12.

The function of the final drive is to change by 90 degrees the direction of the power transmitted through the propeller shaft to the driving axles. It also provides a fixed reduction between the speed of the propeller shaft and the axle shafts and wheels. In passenger cars this reduction varies from about 3 to 1 to 5 to 1. In trucks, it can vary from 5 to 1 to as much as 11 to 1.

The gear ratio of a final drive having bevel gears is found by dividing the number of teeth on the driven or ring gear by the number of teeth on the pinion. In a worm gear final drive, the gear ratio is found by counting the number of revolutions of the worm gear required for one revolution of the driven gear.

Most final drives are of the gear type. Hypoid gears are used in passenger cars and

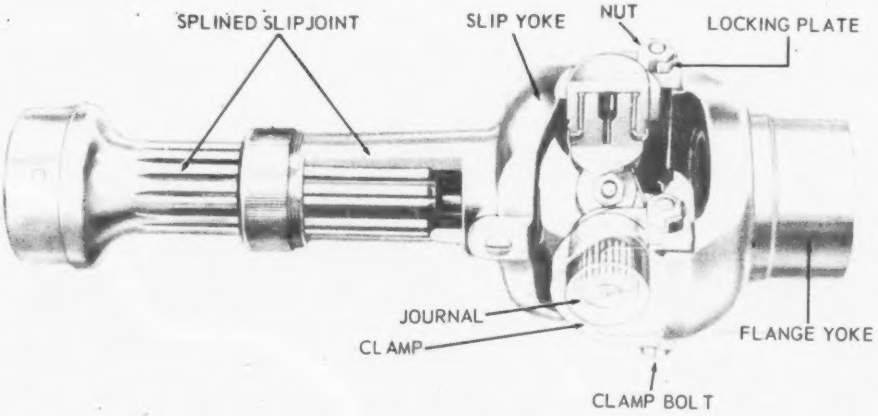


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Figure 4-11.— Slip joint and common type of universal joint.

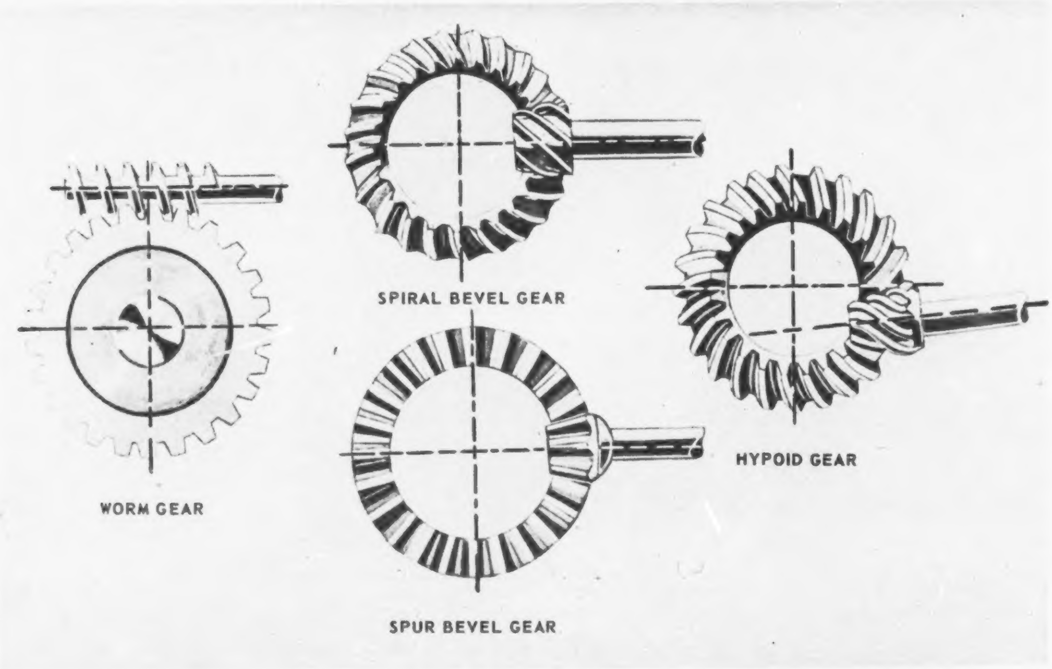

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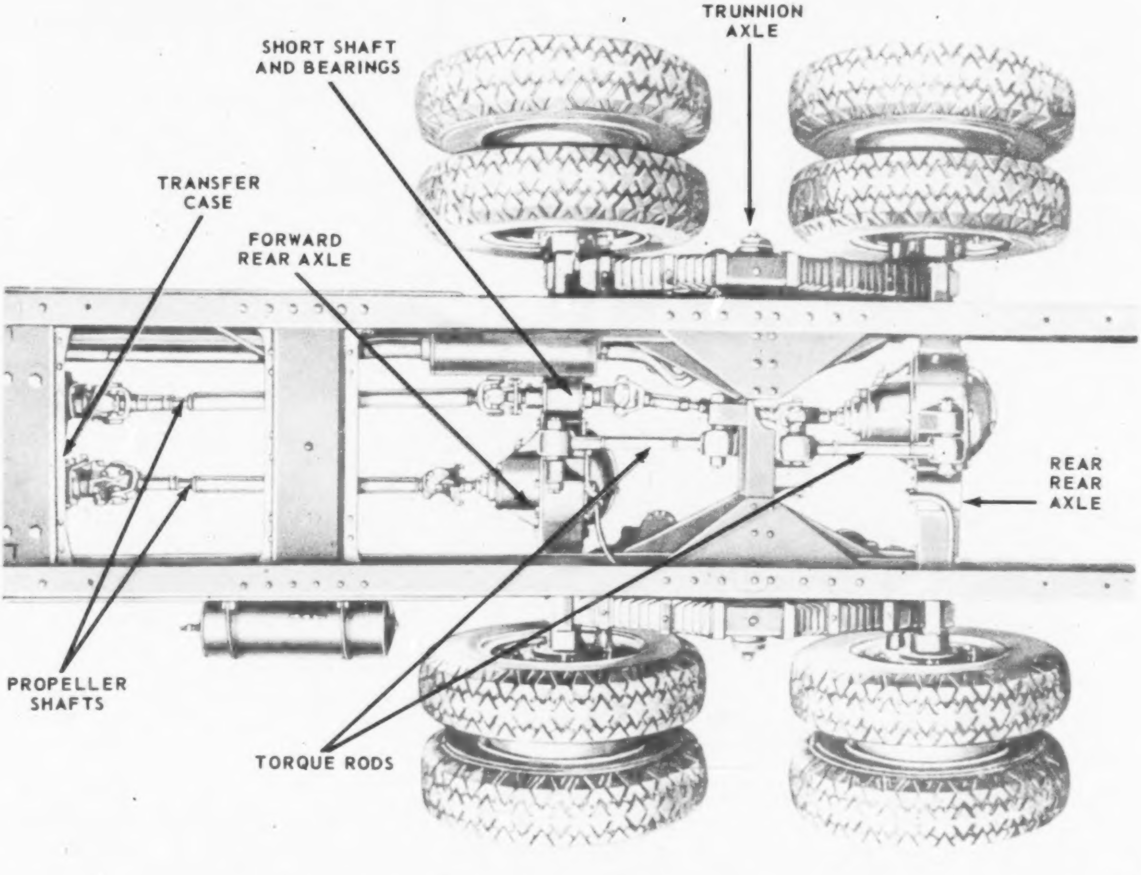
Figure 4-12.—Gears used in final drives.

light trucks to eliminate the rear seat propeller shaft tunnel or to permit a lower body design. They permit the bevel driven pinion to be placed below the center of the ring gear, thereby lowering the propeller shaft (fig. 41-2). Worm gears allow a large speed reduction and are used to a limited extent on larger trucks. Spiral bevel gears are similar to hypoid gears. They are used in both passenger cars and trucks to replace spur gears that are considered too noisy.

DIFFERENTIALS

Associated with the final drive and contained in the rear axle housing is the differential. The purpose of the differential is easy to understand when you compare a vehicle to a company of men marching in mass formation. When the company makes a turn, the men in the inside file must take short steps, almost marking time, while men in the outside file must take long steps and walk a greater distance to make the turn. When a motor vehicle turns a corner, the wheels on the outside of the turn must rotate faster and travel a greater distance than the wheels on the inside. This causes no difficulty for front wheels of the usual passenger car because each wheel rotates independently. However, in order to drive the rear wheels at different speeds, the differential is needed. It connects the individual axle shaft for each wheel to the bevel drive gear. Therefore, each shaft can turn at a different speed and still be driven.

To overcome the situation where one spinning wheel might be undesirable, some trucks are provided with a DIFFERENTIAL LOCK. This is a simple dog clutch, controlled manually or automatically which locks one axle shaft to the differential case and bevel drive gear. Although this device forms a rigid connection between the two axle shafts and makes both wheels rotate at the same speed, it is used very little. Too often the driver forgets to disengage the lock after using it. There are, however, automatic devices for doing almost the same thing. One of these, which is rather



81.199

Figure 4-13.—Bogie 4-wheel drive with independent propeller shafts.

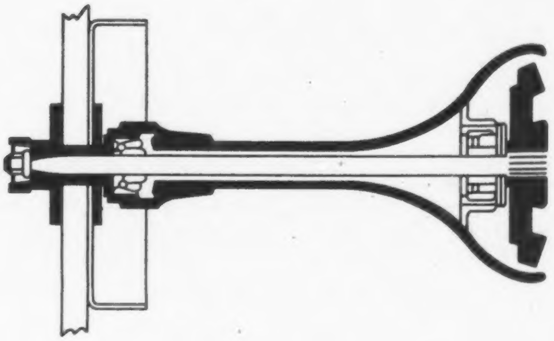
extensively used today, is the high-traction differential. This does not work, however, when one wheel loses traction completely. In this respect it is inferior to the differential lock.

With the no-spin differential one wheel cannot spin because of loss of tractive effort and thereby deprive the other wheel of driving effort. For example, one wheel is on ice and the other wheel is on dry pavement. The wheel on ice is assumed to have no traction. However, the wheel on dry pavement will pull to the limit of its tractional resistance at the pavement. The wheel on ice cannot spin because wheel speed is governed by the speed of the wheel applying tractive effort.

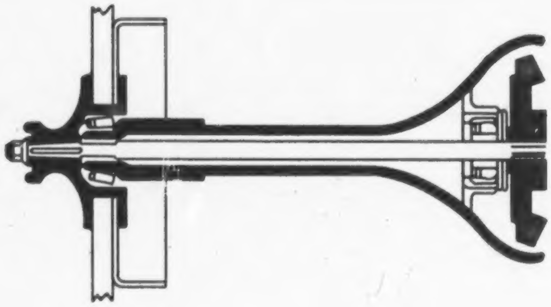
AXLES

A live axle is one that supports part of the weight of a vehicle and also drives the wheels connected to it. A dead axle is one that carries part of the weight of a vehicle but does not drive the wheels.

Usually, the front axle of a passenger car is a dead axle and the rear axle is a live axle. In 4-wheel drive vehicles, both front and rear axles are live axles, and in 6-wheel drive vehicles, all three axles are live axles. The third axle, part of a BOGIE DRIVE, is joined to the rearmost axle by a trunnion axle as shown in figure 4-13. The axle trunnion is attached rigidly



81.200
Figure 4-14.—Semifloating rear axle.



81.201
Figure 4-15.—Three-quarter floating rear axle.

to the frame. Its purpose is to help in distributing the load on the rear of the vehicle to the two live axles which it connects.

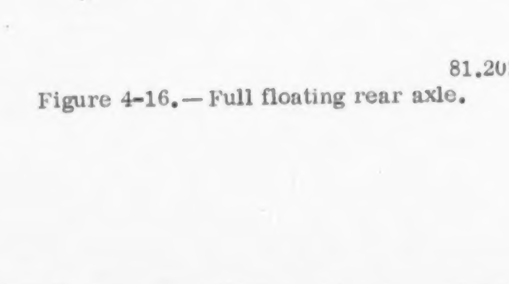
There are FOUR types of live axles used in automotive and construction equipment. They are: plain, semifloating, three-quarter floating, and full floating.

The PLAIN LIVE AXLE, or nonfloating rear axle, is seldom used in construction equipment today. The axle shafts in this assembly are called nonfloating because they are supported directly in bearings located in the center and ends of the axle housing. In addition to turning the wheels, these shafts carry the entire load of the vehicle on their outer ends. Plain axles also support the weight of the differential case.

The SEMIFLOATING AXLE (fig. 4-14) that is used on most passenger cars and light trucks has its differential case independently supported. The differential carrier relieves the axle shafts from the weight of the differential assembly and the stresses caused by its operation. For this reason the inner ends of the axle shafts are said to be floated. The wheels are keyed or bolted to outer ends of axle shafts and the outer bearings are between the shafts and the housing. The axle shafts therefore must take the stresses caused by turning or skidding of the wheels. The axle shaft in a semifloating live axle can be removed after the wheel and brake drum have been removed.

The axle shafts in a THREE-QUARTER FLOATING AXLE (fig. 4-15) may be removed with the wheels, which are keyed to the tapered outer ends of the shafts. The inner ends of the shafts are carried as in a semifloating axle. The axle housing, instead of the shafts, carries the weight of the vehicle because the wheels are supported by bearings on the outer ends of the housing. However, axle shafts must take the stresses caused by the turning, or skidding, of the wheels. Three-quarter floating axles are used in some trucks but in very few passenger cars.

The FULL FLOATING AXLE is used in most heavy trucks. (See fig. 4-16.) These axle shafts may be removed and replaced without



81.202
Figure 4-16.—Full floating rear axle.

removing the wheels or disturbing the differential. Each wheel is carried on the end of the axle tube on two ball bearings or roller bearings and the axle shafts are bolted to the wheel hub. The wheels are driven through a flange on the ends of the axle shaft which is bolted to the outside of the wheel hub. The bolted connection between axle and wheel does not make this assembly a true full floating axle, but nevertheless, it is called a floating axle. A true full floating axle transmits only turning effort, or torque.

MAINTENANCE

There are very few adjustments that must be made to the power train during normal operations. As an operator, your primary duties will be limited to lubrication of the power train. You can reduce repairs by proper lubrication and periodic inspection of these power train units.

Proper lubrication depends upon the use of the right kind of lubricants which must be put in the right places in the amounts specified by the LUBRICATION CHARTS. The charts provided with the vehicle will show what units in the power train will require lubrication, and where they are located.

In checking the level of the lubricant in GEAR CASES, keep these two important points in mind:

First, always carefully wipe the dirt away from around the inspection plug and then use the proper size wrench to remove the inspection plugs. A wrench too large will round the corners and prevent proper tightening of the plug. For the same reason, never use a pipe wrench or a pair of pliers for removing plugs.

Secondly, be sure the level of the lubricant is right—usually just below or on a level with the bottom of the inspection hole. Before checking the level, allow the vehicle to stand for a while on a level surface so the gear oil can cool and find its own level. Gear oil heated and churned by revolving gears expands and forms bubbles. Although too little gear oil in the gear boxes is responsible for many failures of the power train, do not add too much gear lubricant. Too much oil causes extra maintenance.

Excessive oil or grease can find its way past the oil seals or gear cases. It may be forced out of a transmission into the clutch housing and result in a slipping clutch; or it may get by the rear wheel bearings from the differential housing to cause brakes to slip or grab. Always clean differential and live axle housing vents to prevent leaking seals.

UNIVERSAL JOINTS and SLIP JOINTS at the ends of propeller shafts are to be lubricated if fittings are provided. Some of these joints are packed with grease when assembled, others have grease fittings or small plugs, with screwdriver slots, that can be removed for inserting grease fittings. Do not remove these plugs until you consult the manual or your chief for instructions.

Some passenger cars and trucks have a leather boot or shoe covering the universal and slip joints. The boot prevents grease from being thrown from the joints and it also keeps dirt from mixing with the grease. A mixture of dirt and grease forms an abrasive that will wear parts in a hurry. Never use so much grease on these joints that the grease will be forced out of the boot. The extra grease will be lost and the added weight of the grease will tend to throw the propeller shaft out of balance.

When you are to give a vehicle a thorough inspection, inspect the power train for loose gear housings and joints. Look for bent propeller shafts that are responsible for vibrations, and examine the gear housing and joints for missing screws and bolts. Check to see that the U-bolts fastening the springs to the rear axle housing are tight. A loose spring hanger can throw the rear axle assembly out of line, and place additional strain on the propeller shaft and final drive. When making these inspections, always check the sheel lugs for tightness.

After tightening the gear housing, loose connections, and joints, road test the vehicle to see if the various units in the power train are working properly. Shift the gears into all operating speeds and listen for noisy sounds. Report all improper operation of the power train units on the Operator's Trouble Report enabling the mechanic to check out possible causes.

DRIVING WHEELS

Wheels attached to live axles are the DRIVING WHEELS. The number of wheels and number of driving wheels is sometimes used to identify equipment. Wheels attached to the outside of the driving wheels make up DUAL WHEELS. Dual wheels give additional traction to the driving wheels and distribute the weight of the vehicle over a greater area of road surface. They are considered as single wheels in describing vehicles. For example, a 4 x 2 (four by two) could be a passenger car or a truck having 4 wheels with 2 of them driving. A 4 x 4 indicates a vehicle having 4 wheels with all 4 driving. In some cases, these vehicles will have dual wheels in the rear. You would describe such a vehicle as a 4 x 4 with dual wheels.

A 6 x 4 truck, although having dual wheels in the rear, is identified by 6 wheels, 4 of them driving. (See fig. 4-25.) Actually, the truck has 10 wheels but the wheel attached to each driving wheel could be removed without changing the identity, of the truck. If the front wheels of this truck were driven by a live axle, it would be called a 6 x 6.

BRAKE SYSTEMS

Good brakes are an absolute necessity for the safe operation of a motor vehicle. The modern day vehicle is capable of moving at extremely high speeds, and this results in an ever increasing demand for more efficient braking systems. Braking systems must not only be able to stop the vehicle, but must stop it in as short a distance as possible.

Friction is the resistance to relative motion between two surfaces in contact with each other. Thus, when a stationary surface is forced into contact with a moving surface, the resistance to relative motion or the rubbing action between the two surfaces will slow down the moving surface. In nearly all brake systems, the brake drums (see fig. 4-19) provide the moving surface and the brakeshoes provide the stationary surface. The friction between the brake drums and the brakeshoes slows the drum, wheel, and the friction between the tires and the road surface slows the vehicle, eventually bringing it to a complete stop.

INDIVIDUAL BRAKES

On modern equipment individual service brakes are provided for each wheel and are operated by a foot pedal. The equipment also has an emergency or parking brake. The parking brake is operated by a separate pedal or a hand lever.

Individual brakes are classified into three types: external contracting brake, internal expanding brake, and disk brake.

External Contracting Brakes

External contracting brakes are sometimes used for parking brakes on motor vehicles and for controlling the speed of auxiliary equipment drive shafts.

In operation, the brake band (or shoe) of an external contracting brake is tightened around the rotating drum by moving the brake lever. The brake band is made of comparatively thin, flexible steel, shaped to fit the drum, with a frictional lining riveted to the inner surface (fig. 4-17). This flexible brake band cannot withstand the high pressure required to produce the friction that will stop a heavily loaded or fast moving vehicle, but works well as a parking brake.

Figure 4-18 shows an external contracting brake. The brake band is anchored opposite the point where the pressure is applied. In addition to supporting the band, the anchor provides a means for adjusting brake lining clearance. Other adjusting screws and bolts are provided at the ends of the band.

Internal Expanding Brakes

Internal expanding brakes are used almost exclusively as wheel brakes. This type of brake permits a more compact and economical construction. The brakeshoe and brake operating mechanism are supported on a backing plate or brake shield which is attached to the vehicle

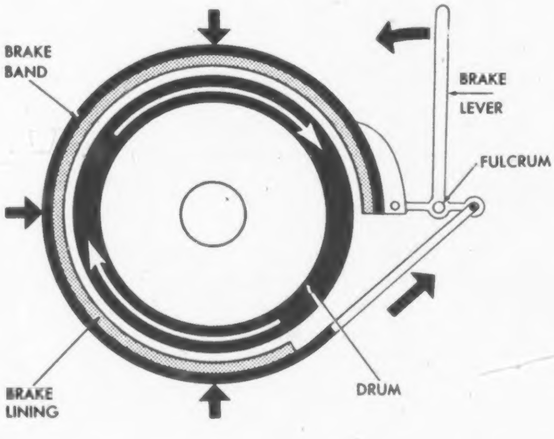


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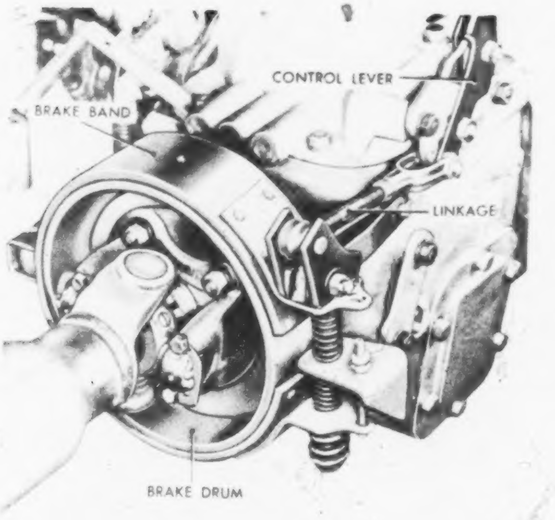
Figure 4-17.—External contracting brake.



81.274
Figure 4-18.—External contracting transmission parking brake.

axle, (see fig. 4-19.) The brake drum, attached to the rotating wheel, acts as a cover for the shoe and operating mechanism and furnishes a frictional surface for the brakeshoe.

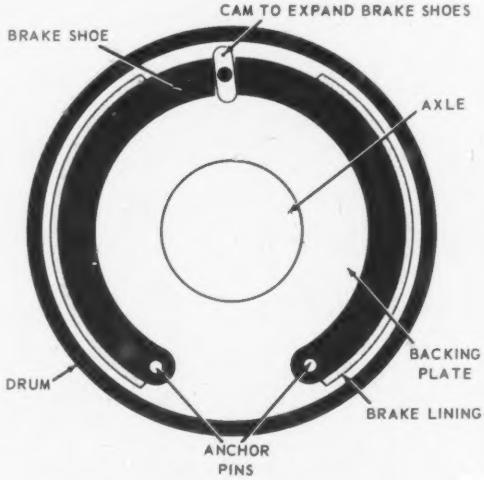
In operation, the brakeshoe of an internal expanding brake is forced outward against the drum to produce the braking action. One end of the shoe is hinged to the backing plate by an anchor pin, while the other end is unattached and can be moved in its support by the operating mechanism. When force from the operating mechanism is applied to the unattached end of the shoe, the shoe expands and brakes the wheel. A retracting spring returns the shoe to the original position when braking action is no longer required.

The brake-operating linkage alone does not provide sufficient mechanical advantage for positive braking. Some means of supplementing the physical application of the braking system has to be used to increase pressure on the brakeshoes. A self-energizing action is very helpful in accomplishing this, once setting of the shoes is started by physical effort. While there are variations of this action, it is always obtained by the shoes themselves, which tend to revolve with the revolving drum.

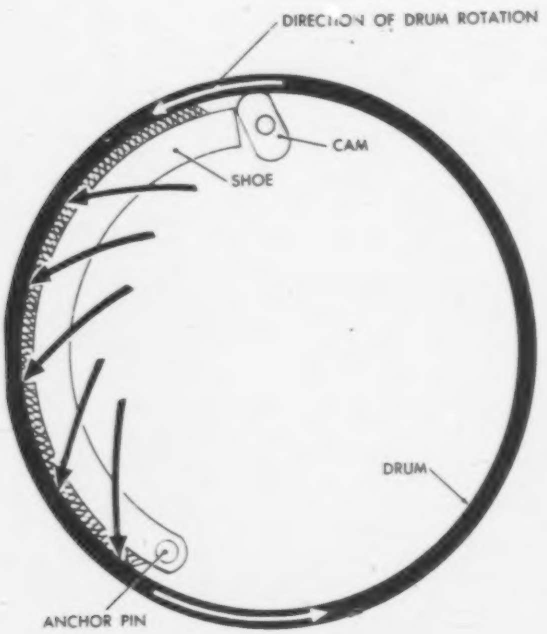
When the brakeshoe is anchored (fig. 4-20) and the drum revolves in the direction shown, the shoe will tend to revolve with the drum when it is forced against the drum. As a result, the shoe will exert considerable pressure against the anchor pin. Since the pin is fixed to the brake shield, this pressure will tend to wedge the shoe tightly in between the pin and the drum as shown. As the initial braking pressure is increased on the cam, the wedging action increases and the shoe is forced still more tightly against the drum to increase the friction. This self-energizing results in more braking action than could be obtained with the actuating pressure alone. Brakes making use of this principle to increase pressures on the braking surfaces are known as self-energizing (or servo) brakes.

It is most important that the operator control the total braking action at all times; therefore, the self-energizing action should increase only upon application of additional actuating pressure at the brake pedal. The amount of self-energizing action available depends mainly on location of the anchor pin. As the pin is moved toward the center of the drum, wedging action increases until a point is reached where the shoe will automatically lock. The pin must be located outside this point so that the operator can control the braking.

When two shoes are anchored on the bottom of the backing plate, self-energizing action is



81.275
Figure 4-19.—Internal expanding brake.



81.277
Figure 4-20.—Brakeshoe self-energizing action.

effective on only one shoe. The other shoe tends to revolve away from its pivot, which reduces its braking action. When the wheel is revolving in the opposite direction, the self-energizing action is produced on the opposite shoe.

Two shoes are usually mounted so that self-energizing action is effective on both. This is accomplished by pivoting the shoes to each other and leaving the pivot free of the backing plate. The only physical effort required is for operating the first, or primary, shoe. Both shoes then apply additional pressure to the braking surfaces with no increase in the pressure on the operating linkage. The anchor pins are fitted into slots in the free ends of the brakeshoes. This method of anchoring allows the movement of the shoes necessary to expand against the drum when the shoes are forced against the drum, and the self-energizing action of the primary shoe is transmitted through the pivot to the secondary shoe (fig. 4-21). Both shoes will tend to revolve with the drum and will be wedged against the drum by the one anchor pin. The other anchor pin will cause a similar action when the wheel is revolving in the opposite direction.

The operating mechanism for wheel brakes differs with the brake systems, and so do the brakeshoe adjusting devices. The brake drums and brakeshoes, however, are similar in all wheel brakes.

Most modern automotive brakes have a self-adjusting feature that automatically adjust the brakes when they need it as a result of brake lining wear.

Disk Brakes

The disk brake has a metal disk instead of a drum, and a pair of flat pads instead of curved brakeshoes. Figure 4-22 shows a sectional view of a typical disk brake assembly. The two flat pads, are located on the two sides of the disk. The assembly in which the flat pads are held is called the caliper assembly. In operation, the pads are forced against the two sides of the disk by the movement of pistons in the

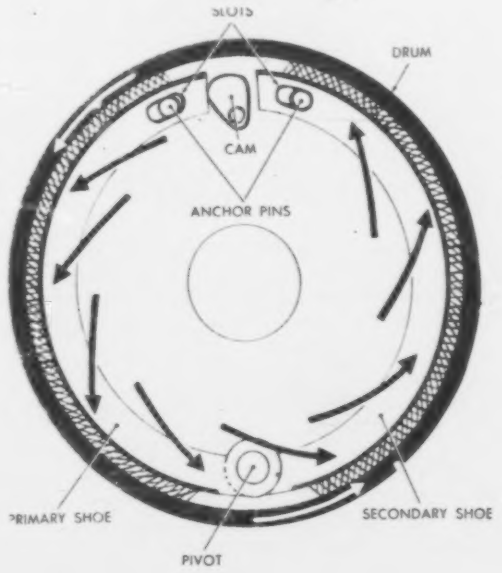


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Figure 4-21.—Schematic showing primary and secondary brakeshoes.

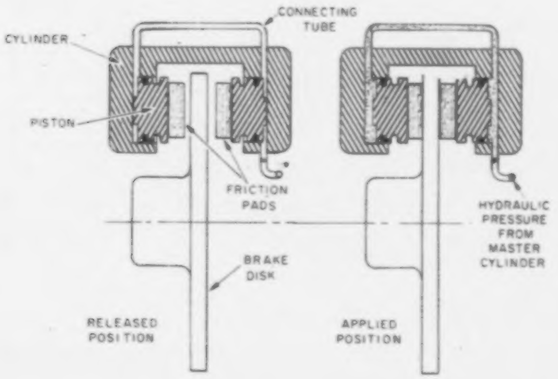

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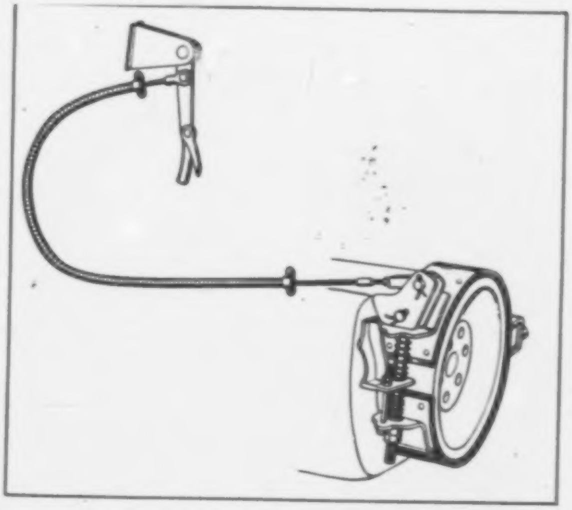
Figure 4-22.—Sectional view of disk brake in released and applied position.



81.457
Figure 4-23.—Typical parking brake (external band transmission type).

caliper assembly. The pistons are actuated by hydraulic pressure from the master cylinder. The effect is to clamp the rotating disk between the stationary pads as illustrated in figure 4-22. This is the same action you get when you pick up a piece of paper; your fingers and thumb clamp on both sides of the paper to hold it. In the same way, the pads apply friction to the disk and attempt to stop its rotation. This provides the braking action.

MECHANICAL HANDBRAKES

In most automotive vehicles, the handbrake has its own hookup (fig. 4-23). Either external-contracting brake bands are located on the drive shaft or some type of mechanical linkage operates the rear wheel brakes (fig. 4-24).

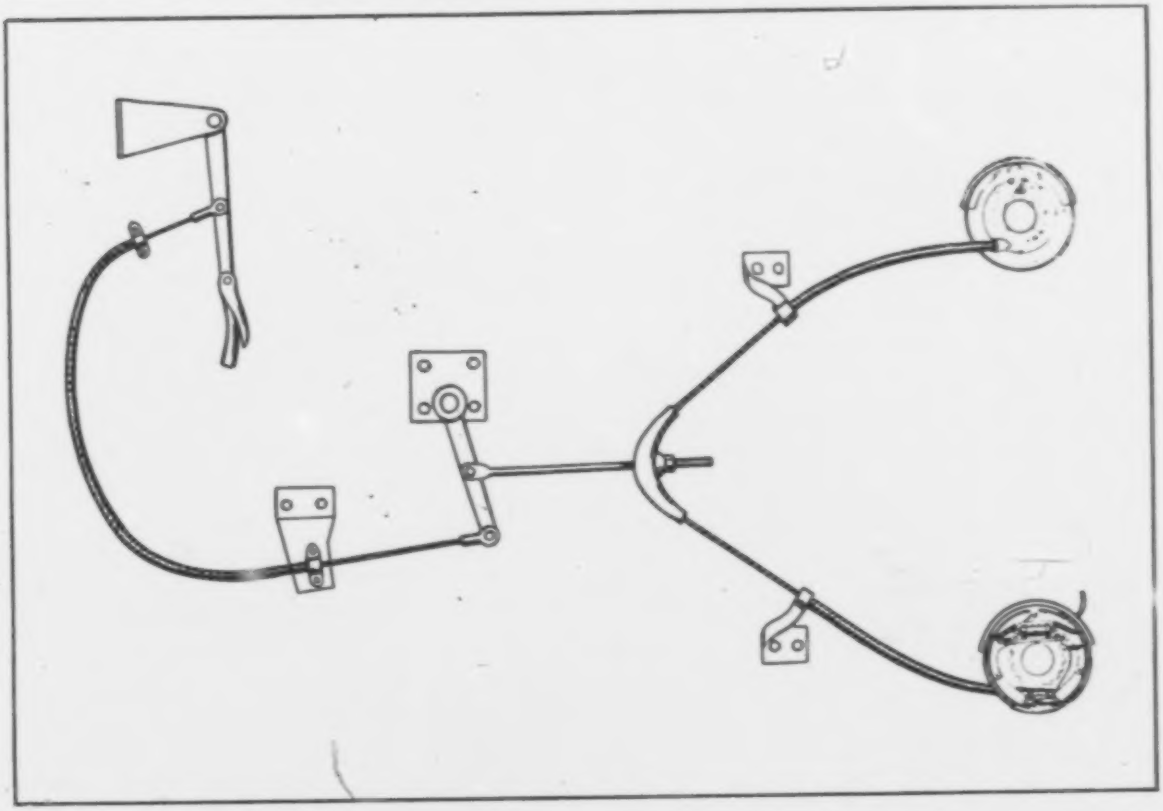
HYDRAULIC BRAKE SYSTEMS

A hydraulic brake system is primarily a liquid connection or coupling between the brake pedal and the individual brakeshoes and drums. (See fig. 4-25.) The system consists of one master cylinder connected by pipes and flexible tubing to the wheel cylinders. The wheel cylinders control the movement of the brakeshoes at each wheel.

The brake fluid in hydraulic systems is composed of alcohol and caster oil or glycerin. This liquid neither freezes nor boils at temperatures encountered in year round operations. When the brake pedal in a hydraulic brake system is depressed, the hydraulic fluid forces the pistons in the wheel cylinder against the brakeshoes. The shoes expand against the brake drum and stop the vehicle. Hydraulic brakes are SELF-EQUALIZING BRAKES. If the actuating pistons were all the same size, each brake in the hydraulic system would receive an identical hydraulic force when the brakes are applied because a force exerted at any point upon a closed liquid is distributed equally through the liquid in all directions. Some brake systems have larger wheel cylinders in the front than in the rear. This is because, when stopping, more of the vehicle's weight is felt in front and, therefore, more front wheel braking effort is required.

The mechanical advantage of any brake system is the relation between the pressure applied by the operator on the brake pedal to the pressure exerted on the braking surfaces.

The master cylinder has two functions. It is a reservoir for the brake fluid, and it contains the piston and the valves which change mechanical force to hydraulic pressure when the brake pedal is depressed. (See fig. 4-25.) The pressure on the brake pedal moves the piston within the master cylinder, forcing the brake fluid from the master cylinder through tubing and flexible hose to the wheel cylinders. As pressure on the pedal is increased, greater hydraulic pressure



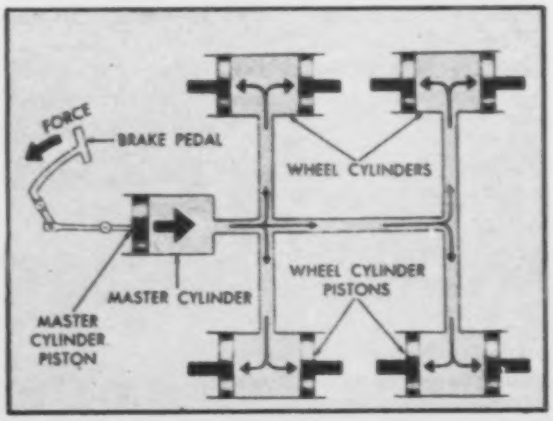
81.458

Figure 4-24.—Typical parking brake (integral type).

is built up within the brake cylinders, and thus greater force is put forth against the ends of the brakeshoes. When pressure on the pedal is released, the springs on the brakeshoes return the wheel cylinder pistons to their released positions. This action forces the brake fluid back through the flexible hose and tubing to the master cylinder.

Most older model cars are equipped with the single system master cylinder. This system is, however, being replaced with dual system master cylinders.

The operation of a dual system master cylinder is basically the same as a single master cylinder. The dual system master cylinder, however, has two pistons, two separate fluid reservoirs, and two output ports. Thus, the dual system master cylinder has two separate hydraulic pressure systems. One of the hydraulic systems normally is connected to the front



81.280

Figure 4-25.—Diagram of the operation of a hydraulic brake system.

brakes, and the other system is the rear brakes. If either the front or rear hydraulic system fails, the other system remains operational.

The master cylinder, like other parts in the brake system, is subject to wear, leaks, and deposits or corrosion on the cylinder wall and piston. Master cylinder reservoir fluid level should be checked periodically and clean brake fluid added, as needed, to maintain fluid level approximately 1/2" from the top of the reservoir.

The BRAKE LINES transmit fluid and pressure from the master cylinder to the WHEEL CYLINDERS, which in turn change the hydraulic pressure into mechanical force. The wheel cylinders are mounted on the brake backing plate. Inside each cylinder are two pistons that move in opposite directions by hydraulic pressure, which pushes the BRAKESHOES against the BRAKE DRUM. The brakeshoes are made of iron, steel, or cast aluminum. They support the brake lining and transmit force to the lining, which is attached to the face of the shoe and make contact with the inner surface of the brake drums. During contact with one another the lining and the drum create the frictional surface that gives the braking effect.

AIRBRAKE SYSTEMS

Air, like all gases, is easily compressed. Compressed air exerts pressure and this pressure will be equal in all directions. Air under pressure can be conveniently stored and carried through lines or tubes. Considerable force is available for braking since operating air pressure may be as high as 100 psi. All brakes on a vehicle, and on a trailer (when one is used), are operated together by means of a brake valve. This valve and the relative location of most of the basic assemblies of an air brake system are shown in figure 4-26 and discussed in the following paragraphs.

The COMPRESSOR is driven from the engine crankshaft or one of the auxiliary shafts. The three common methods of driving the compressor from the engine are gear, belt, and chain.

The compressor may be lubricated from the engine crankcase or be self-lubricated. Cooling may be either by air or liquid from the engine.

The purpose of the compressor GOVERNOR is to automatically maintain the air pressure in the reservoir between the maximum pressure desired (100-105 psi) and the minimum pressure required for safe operation (80-85 psi) by starting and stopping compression.

The two steel tanks, figure 4-26, which are components of most air brake systems are called RESERVOIRS. These tanks are used to cool, store, and remove moisture from the air and give a smooth flow of air to the brake system.

A SAFETY VALVE consists of an adjustable spring-loaded ball check valve in a body. It is used to protect the system against excessive pressures and is usually mounted on a reservoir. The safety valve is normally set at 150 psi but can be varied to suit the vehicle requirements.

A PRESSURE GAUGE is attached to any line which registers reservoir pressure and is mounted to the dash board of the vehicle.

The BRAKE VALVE is the operator's control of the air brake system. When the brake valve is engaged, air from the reservoir flows through the valve to the brakes. The three types of brake valves used in the air brake systems are pedal, treadle, and hand. When you press the pedal of an airbrake system, air under pressure in a reservoir is released to the brake lines by an air valve. This air goes to the brake chambers located close to the wheel brakes, which contain flexible diaphragms. The force of the air admitted to these chambers causes the diaphragms to operate the brakeshoes through a mechanical linkage as shown in figure 4-26.

An air pressure gage will let you know if you have proper air pressure within the reservoir (60 lbs pressure is minimum). This gage is usually found on the instrument panel of a truck or bus. If the pressure fails to build up or exceeds the maximum limits after building up, secure the truck until the fault is corrected.

Independent control of trailer brakes is valuable under adverse conditions when it is sometimes desirable to apply the brakes on the trailer without applying the brakes on the truck or tractor. The independent trailer control valve (fig. 4-27), conveniently located in the cab, provides the operator with perfect control of his trailing load at all times.

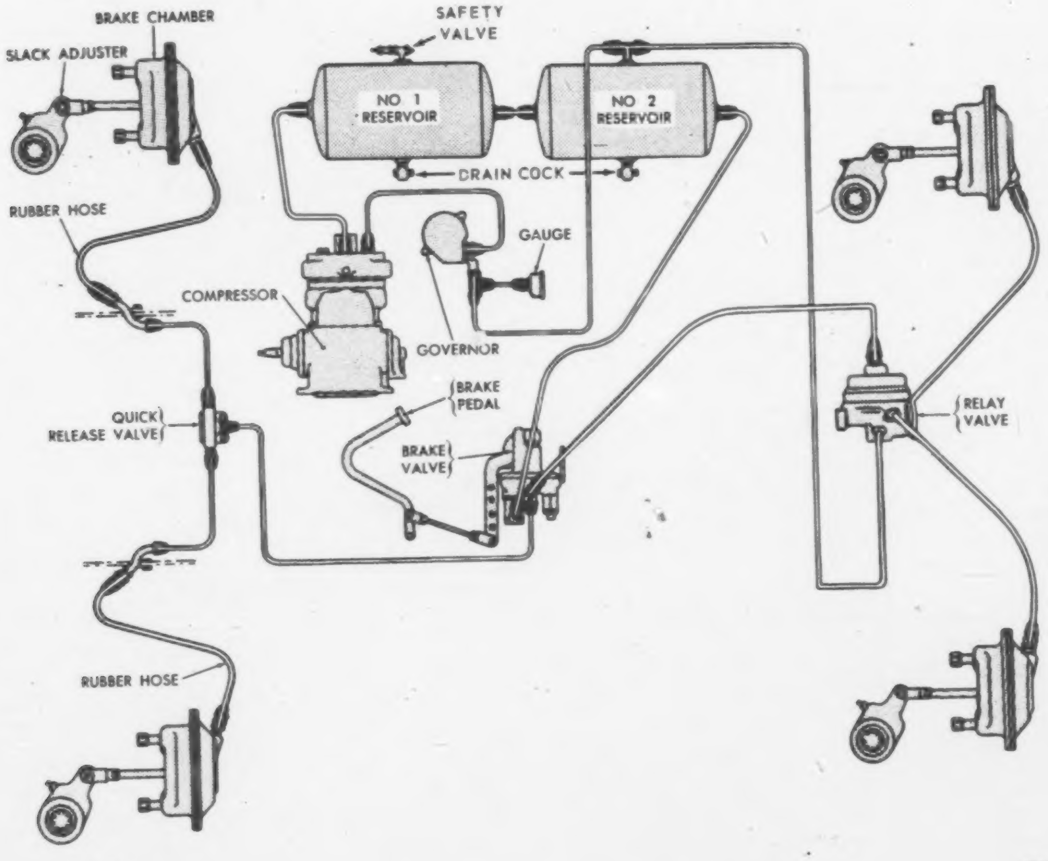


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Figure 4-26.—Diagram of typical airbrake system.

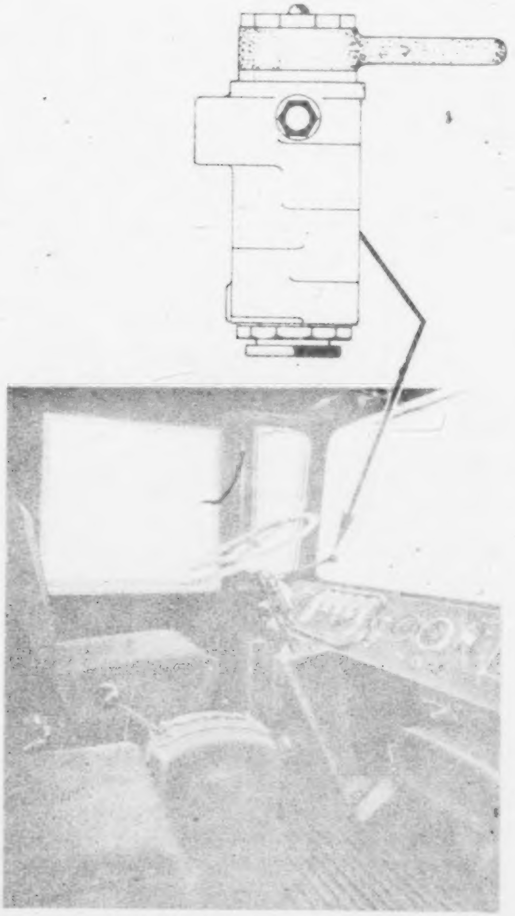
VACUUM BRAKES

In the vacuum brake system, depressing the brake pedal opens a valve between the power cylinder, which contains a piston, and the intake manifold to which the power cylinder is connected (see fig. 4-28). To apply the brakes, air is exhausted from the cylinder ahead of the piston, while atmospheric pressure acts on the rear side of the piston to exert a powerful pull on the rod attached to the piston.

When the brake valve is closed, the chamber ahead of the piston is shut off from the intake manifold and is open to the atmosphere. The pressure is then the same on both sides of the piston; therefore, no pull is exerted upon the pull rod. The brakeshoe return springs then release the brakes and return the piston to its original position in the power cylinder.

HYDROVAC is a trade name for a one-unit vacuum power braking system. It combines into one assembly a hydraulic control valve, a vacuum power cylinder, and a hydraulic slave cylinder. This assembly (fig. 4-29) is connected to both the master cylinder and the wheel brakes, eliminating the need for mechanical connections with the brake pedal.

When you press the brake pedal, fluid is forced from the master cylinder through the check valve to the slave cylinder and on to the wheel cylinders. The foot pedal pressure, acting through the master cylinder, acts also against

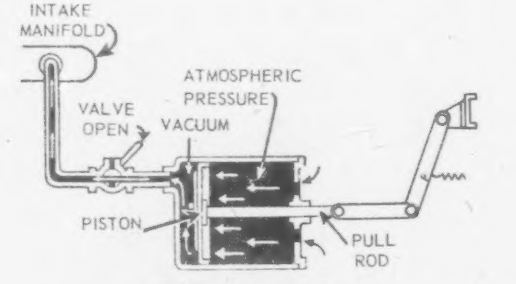


115.429
Figure 4-27.—Hand-type brake valve.

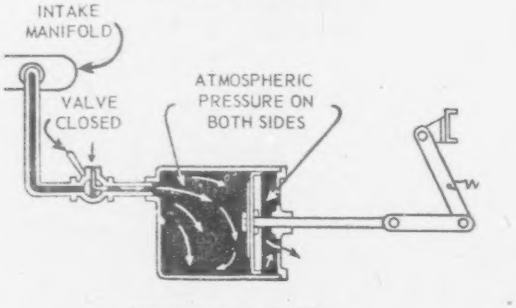
the slave cylinder piston, assisting the vacuum pistons and push rods to press upon the brakeshoes.

OPERATOR MAINTENANCE

Periodic brake service by the operator includes the use of proper brake fluid; checking brake fluid level; inflating tires properly; checking for loose connections or parts; checking for leaks in the system; draining air reserviors daily; and checking the self-contained lubricating oil system of air compressors daily.



PRESSURE APPLIED



PRESSURE RELEASED

81.297
Figure 4-28.—Action of vacuum power brake cylinder.

MALFUNCTION DETECTION

The types of brake trouble that may be encountered in vehicle operation are: Brake pedal goes to the floorboard with no resistance; one brake drags; all brakes drag; vehicle pulls to one side when braking; soft or spongy pedal; excessive pedal effort required; noisy brakes; air in the system; loss of brake fluid; brakes heat up during driving and fail to release; leaky brake cylinder; grabbing braking action; and brake pedal can be depressed without slowing the vehicle. As an operator, you must explain the malfunction on the Operator's Trouble Report and turn it into the maintenance shop for necessary correction.

STEERING MECHANISMS

Though steering may be a simple operation, the steering mechanism is rather complex. In figures 4-30 and 4-31, you see a schematic diagram of a steering mechanism and an illustration of an actual steering system.

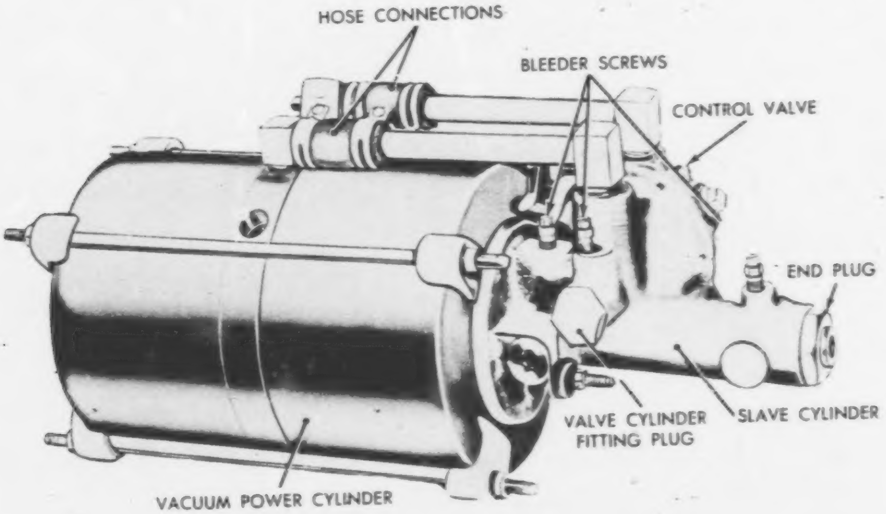


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Figure 4-29.—Hydrovac power brake cylinder.

All steering mechanisms have the same basic parts. The STEERING LINKAGE ties the front wheels together and connects them to the STEERING GEAR case at the lower end of the steering column, which in turn connects the gear case to the steering wheel.

The arms and rods of the steering linkage have ball or ball and socket ends to provide a swivel connection between them These jointed ends are provided with grease fittings, dust seals or boots, and many of them have end-play

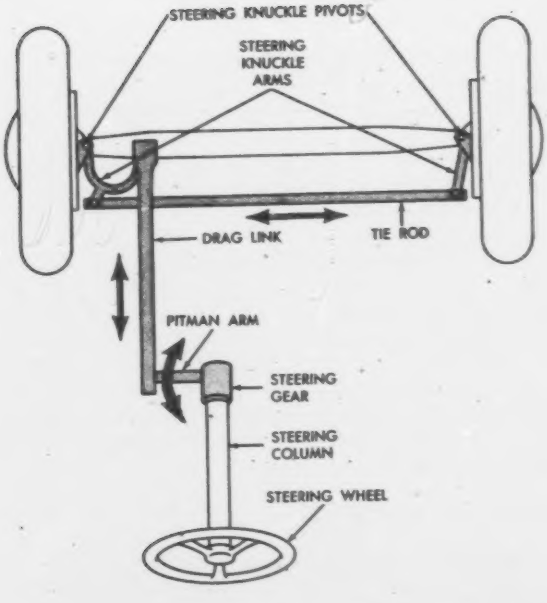

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Figure 4-30.—Steering linkage assembly.

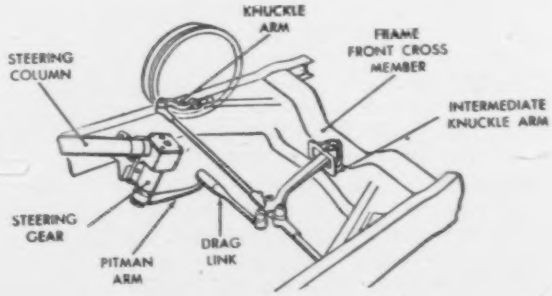

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Figure 4-31.—Steering assembly.

adjustment devices. These joints and devices must be adjusted and lubricated regularly.

The arms, rods, and joints of steering linkages in your equipment may be arranged differently from those shown in figure 4-39, but you will find them in the same general location in the front and underneath the vehicle.

The TIE-ROD, for example, is usually located behind the axle and keeps the front wheels in proper alignment. To provide for easier steering and maximum leverage, the tie-rod may be separated into two lengths and connected to the steering gear near the center of the vehicle. (See fig. 4-39.)

The DRAG LINK between the steering arm and the pitman arm may be long or short, depending on the installation.

The PITMAN ARM, splined to the shaft extending from the steering gear case, moves in an arc, its position depending on which way the steering wheel is turned. It is approximately vertical when the front wheels are straight ahead. Therefore, the length of the drag link is determined by the distance between the steering arm and the vertical position of the pitman arm. Unlike the tie-rods, the length of the drag link is not adjustable.

The steering gear case contains the gears that control the movement of the pitman arm and steering linkage. Figure 4-32 shows a typical steering gear assembly, the location of adjustment screws, and the pipe plug for gear lubricant.

POWER STEERING

Power steering has been used for a number of years on heavy-duty applications, but it is only in recent years that power steering has been applied to any extent on automotive vehicles. The principle of power steering is very simple. A booster arrangement is provided which is set in operation when the steering wheel is turned. The booster then takes over and does most of the work of steering. Power steering has used compressed air, electrical mechanisms, and hydraulic pressure. Hydraulic pressure is used on the vast majority of power-steering mechanisms today.

In the hydraulic power-steering system, a continuously operating pump provides hydraulic pressure. As the steering wheel is turned, valves are operated to admit this hydraulic pressure to a cylinder. Then, the pressure causes a piston to move—and the piston does most of the steering work.

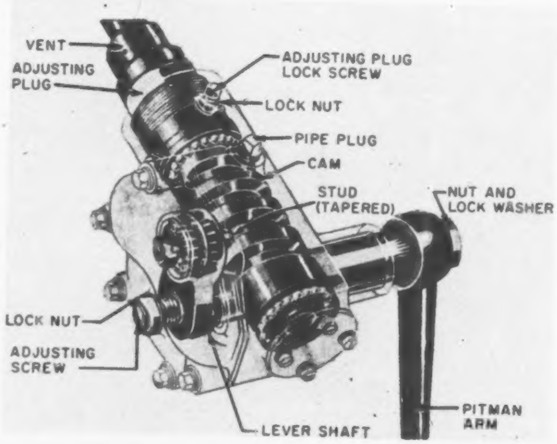

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Figure 4-32.—Steering gear unit of the cam and lever type.

There are actually two general types of power-steering systems. In one, the integral type, the power operating assembly is located in the steering gear case. In the other, the linkage type, the power operating assembly is part of the steering linkage. Figure 4-33 shows a power-steering system of the integral type.

In the linkage-type power-steering system, the power cylinder or booster cylinder is not part of the steering gear. Instead, the power cylinder is connected into the steering linkage. In addition, the valve assembly is included in the steering linkage, either as a separate assembly or united with the power cylinder. Figure 4-34 shows, in phantom view, a power-steering system of the linkage type.

WHEEL ALIGNMENT

Steering control depends greatly upon the position of the wheels in relation to the rest of the vehicle and the surface over which it travels. Any changes from the specified setting of the wheels affect steering and the riding

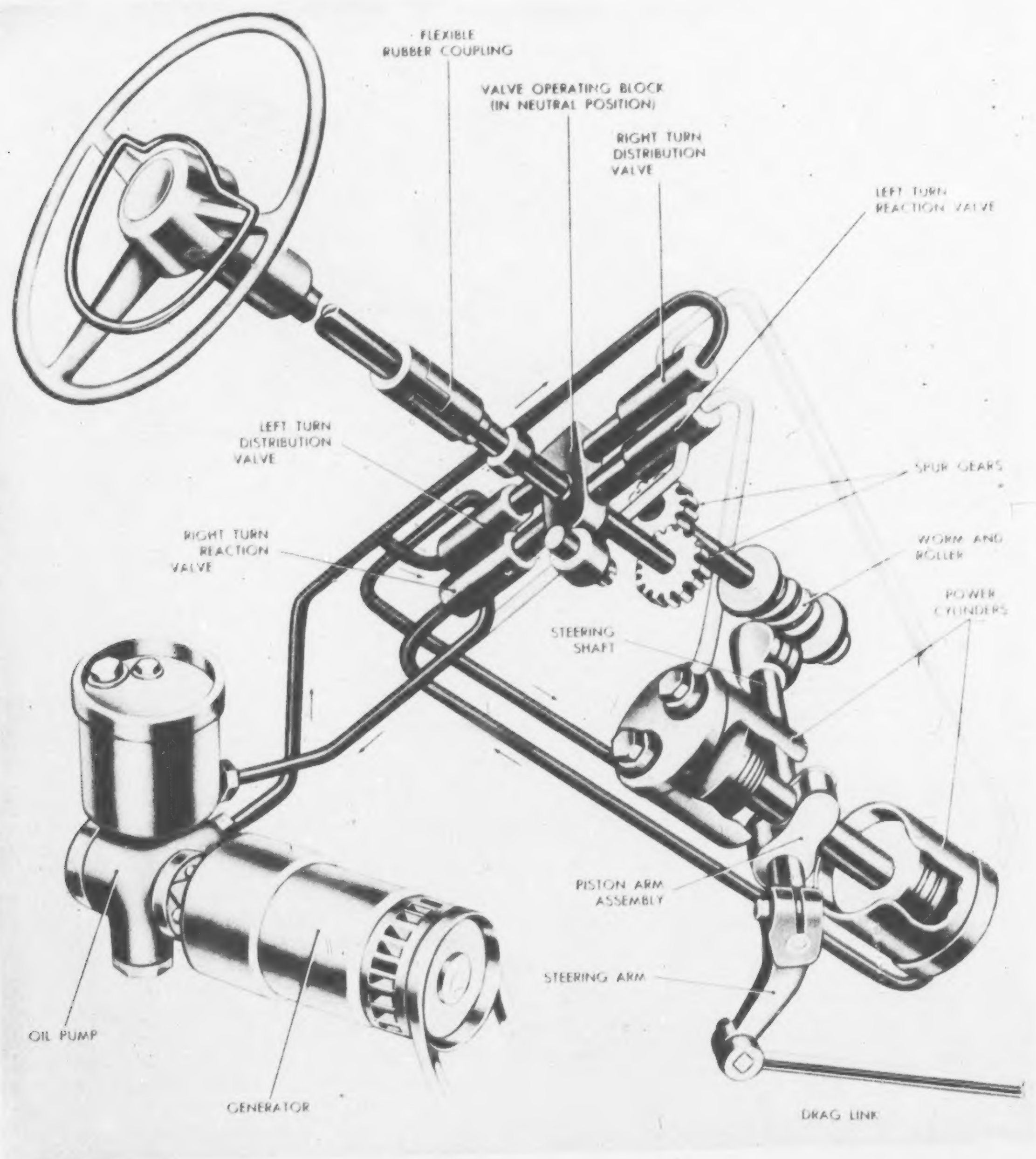

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Figure 4-33.—Integral-type power-steering system.

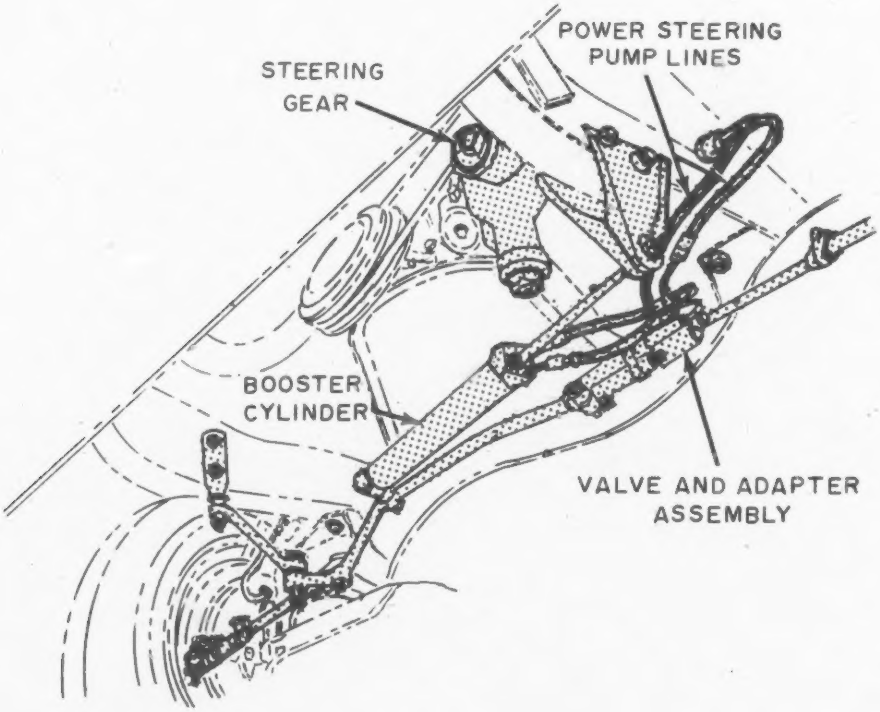

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Figure 4-34.—Linkage-type power-steering system.

control of the vehicle. Therefore, the proper WHEEL ALIGNMENT is important for vehicle control.

STEERING GEOMETRY is the term manufacturers use to describe steering and front wheel alignment. Steering geometry includes PIVOT INCLINATION, wheel CASTER, wheel CHAMBER, TOE-IN and TOE-OUT. These terms refer to angles in the front wheel alignment which may change because of driving over rough terrain, striking stationary objects, and accident damage.

OPERATOR MAINTENANCE

During maintenance servicing by the operator, the service that the steering linkage normally requires is periodic lubrication of the connecting joints between the links which contain bushings.

When vehicles are equipped with manually operated steering, check the steering gear housing for sufficient lubrication and add recommended manufacturer's gear lubricant, if necessary. For vehicles equipped with power steering, check belt tension which can cause low oil pressure and hard steering. Check fluid level. If the fluid level is low, add fluid to bring it up to the recommended level. Use only special power steering fluid recommended. If the level is low, the possibility exists that there is a leak. Check all hose and power-steering connections for signs of leaks. Leakage may occur at various points in the power-steering unit if the seals are defective. Report conditions to the maintenance shop for replacement of any defective seal, or it may only be necessary to tighten the connections to eliminate leaks.

MALFUNCTION DETECTION

The types of steering trouble that may be encountered in vehicle operation are: excessive play in the steering system; hard steering; vehicle wanders; vehicle pulls to one side when braking; front wheel shimmy at low speeds; front-wheel tramps (high speed shimmy); steering kickback; tires squeal on turns; improper tire wear; and noises. As an operator, you would explain the malfunction on the Operator's Trouble Report and turn it into the maintenance shop for corrective action.

SUSPENSION SYSTEMS

A suspension system is a system of ANCHORING and SUSPENDING the wheels or tracks from the frame by means of springs. The suspension system is an important feature of military vehicles; it supports the weight and allows them to be driven under varying loads and speed conditions over bumpy roads and rough terrain without great risk of damage.

The usual components of a suspension system are the SPRINGS and SHOCK ABSORBERS. Some suspension systems also have TORSION BARS.

SPRINGS

Springs support the frame and the body of the vehicle, as well as the load the vehicle carries. They allow the wheels to withstand the shocks of uneven road surfaces and provide a flexible connection between the wheels and the body. The best spring is the one which absorbs road shock rapidly and returns to its normal position slowly. Such a spring, however, is very rare, if not an impossibility. Extremely flexible, or soft springs allow too much movement of the vehicle superstructure, while still, hard springs do not allow enough movement.

The springs do not support the weight of the wheels, rims, tires, and axles. These parts make up the unsprung weight of the vehicle. The unsprung weight decreases the action of the springs and is, therefore, kept to a minimum to permit the springs to do the job of supporting the vehicle frame and load.

The three types of spring suspension usually found in vehicles are: the LONGITUDINAL, the lengthwise mounting, which is the most common; the INDEPENDENT, which is generally used in front suspensions; and TRANSVERSE, which is the crosswise mounting.

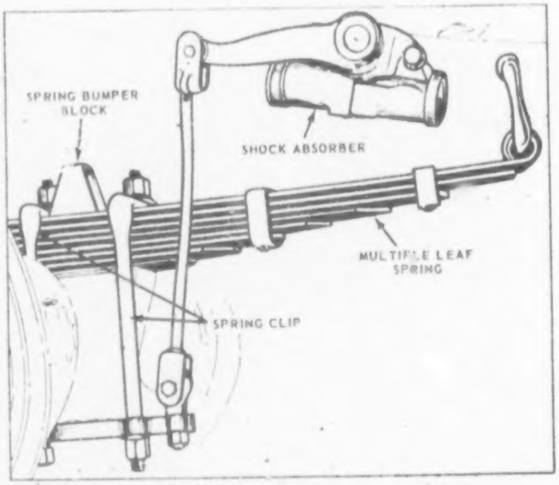

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Figure 4-35.—Multiple leaf spring.

The MULTIPLE LEAF SPRING is shown in figure 4-35. It consists of a number of steel strips or leaves of different lengths, fastened together by a bolt through the center. Each end of the largest or master leaf is rolled into an eye which serves as a means of attaching the spring to the spring hanger and spring shackle. Leaf rebound clips surround the leaves at two or more intervals along the spring to keep them from separating on the rebound after the spring has been depressed. The clips allow the spring leaves to slide but prevent them from separating and throwing the entire rebound stress on the master leaf. Thus the spring acts as a flexible beam. Leaf springs may be suspended lengthwise (parallel to the frame), or crosswise.

When installed LENGTHWISE, both ends of the spring are attached to the frame and the center is clamped to the axle or spring seat. (See fig. 4-36.) In some trucks and cars the rear springs are clamped under the axle, instead of over it to lower the center of gravity. A low center of gravity will help prevent a heavily loaded truck from upsetting.

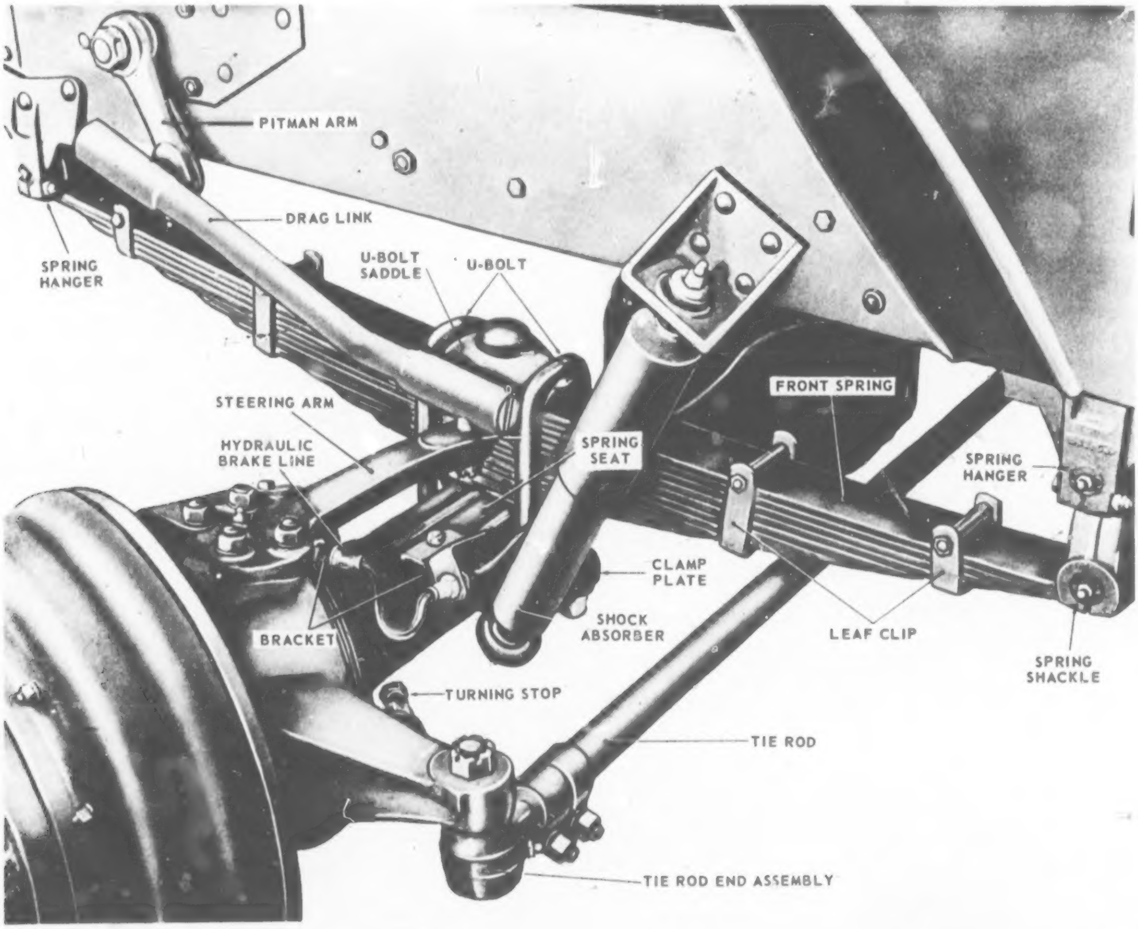

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Figure 4-36.—Detail of front axle suspension system.

Springs installed CROSSWISE have the ends attached to the axle, and the frame rests on the center of the spring. Torque arms or radius rods are required with this type of spring suspension to absorb the driving thrust of the wheels. The driving thrust and brake action of wheels tend to twist the springs from the spring hangers and shackles connecting them to the frame or axles.

Spring hangers are fittings to which the spring ends are attached. A bolt or pin passes through the bushing in the spring eye and is secured to the spring hanger on the frame. The bushing and shackle bolt or pin, therefore, provide the bearing surface which supports the load on the spring.

The SPRING BUSHINGS may be made of bronze or rubber. They may be pressed or screwed into the spring eye, depending on the design. The steel bolts or pins that pass through the bushing are also either plain or threaded. Threaded bushings and shackle bolts offer a greater bearing surface and are replaced more easily when they become worn.

When a leaf spring is compressed it must straighten out or break. Therefore, SPRING

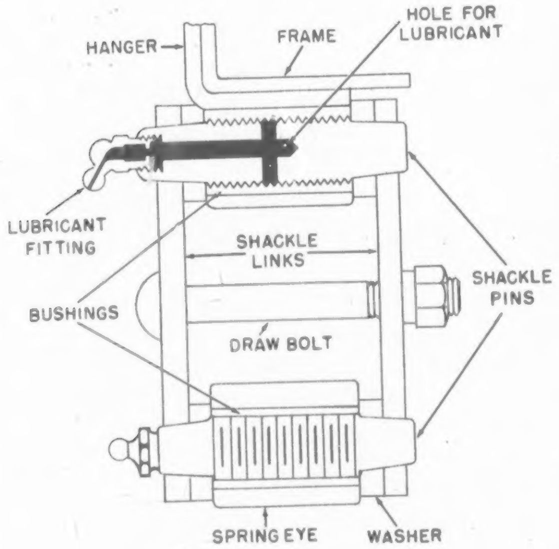

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Figure 4-37.—Cross section of link shackle showing spring bushings and pin.

SHACKLES are required at one or both ends of the spring. Spring shackles provide a swinging support and allow the spring to straighten out when compressed. One shackle is used in either the front or rear support of springs installed lengthwise. Two shackles are used in supporting springs installed crosswise. Figure 4-37 shows how a leaf spring is attached to a frame by a spring shackle.

You will see many types of spring shackles. The link shackle and U-shackle are the most common. Link shackles are used in heavy vehicles, and the U-type is more common for use on passenger cars and light trucks.

You will find link shackles used to support a transverse spring on the dead front axle of some wheeled tractors. Most wheeled tractors do not even have springs, and all load cushioning is obtained through large, low pressure tires.

Track-type tractors are equipped with one large leaf spring (fig. 4-38) supported without spring shackles. It is fastened to the engine support and rests on the frames supporting the tracks and rollers. Brackets on the track frames keep the spring from shifting. The main purpose of the spring is to relieve the running gear of stresses during operation.

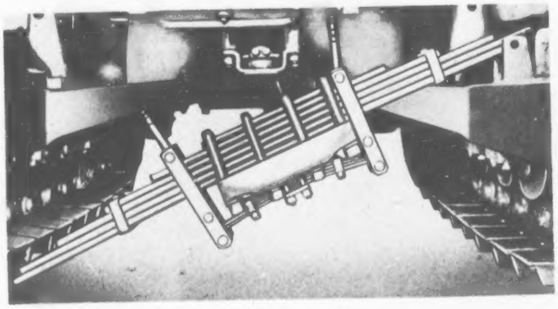

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Figure 4-38.—A partially removed tracklayer spring.

Some vehicles are equipped with leaf springs at the rear wheels only; others are so equipped both front and rear.

COIL SPRINGS (fig. 4-39) are most generally used on independent suspension systems. They provide a very smooth riding quality. Their use has normally been limited to passenger vehicles. Recently, however, they have been used to a limited extent on trucks.

In figure 4-40, you see how a coil spring is mounted. The spring seat and hanger, shaped to fit the coil ends, hold the spring in place. Spacers made of rubberized fabric are placed at each end of the coil to prevent squeaking. The rubber bumper, mounted in the spring supporting member, prevents metal to metal contact when the spring is compressed. Most vehicles are equipped with coil springs at the two front wheels, while some others have them at both front and rear.

SHOCK ABSORBERS

Springs alone are never satisfactory in a light vehicle suspension system. A stiff spring gives a hard ride because it does not flex and rebound when the vehicle passes over a bump. On the other hand, too flexible a spring rebounds too much, and the vehicle rides roughly. To smooth the riding qualities of the vehicle, SHOCK ABSORBERS are used. They prevent

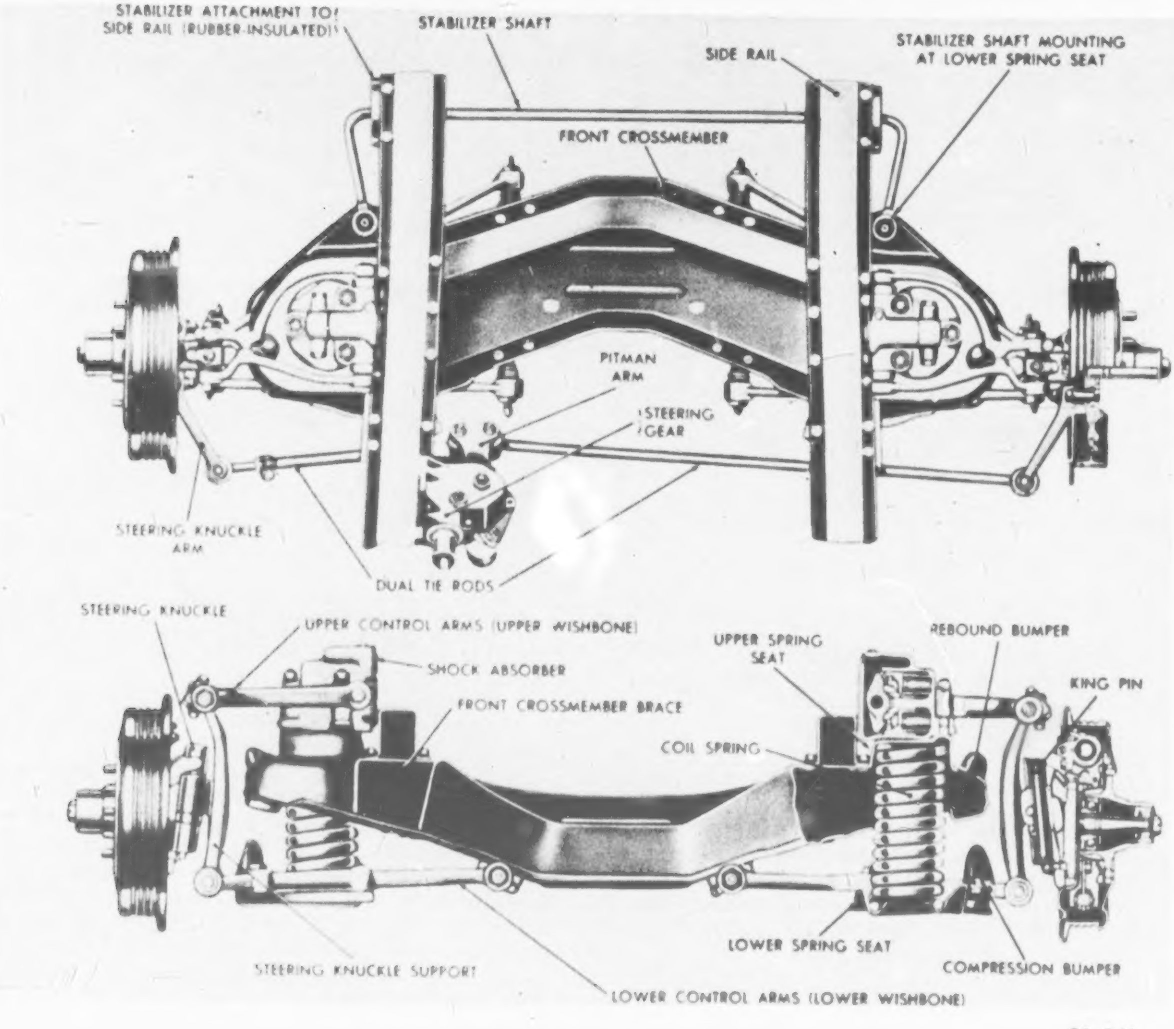

Figure 4-39.—Coil spring suspension.

81.241

excessive jolting of the vehicle by balancing spring stiffness and flexibility. They allow the springs to return to rest slowly after having been compressed. Although SINGLE-ACTING shock absorbers check only spring rebound, DOUBLE-ACTING shock absorbers check spring compression as well as spring rebound, permitting the use of the more flexible springs.

FRONT AXLE SUSPENSION

Most passenger car front wheels are individually supported with independent suspension systems. The ones you are likely to encounter are the coil spring and the torsion bar suspension systems. These are used with independent front axles and shock absorbers.

REAR AXLE SUSPENSION

Driving wheels are mounted on a live driving axle that is suspended by springs attached to the axle housing. (Refer to fig. 4-18.) Leaf springs are generally used for suspending live axles using Hotchkiss drive as illustrated in

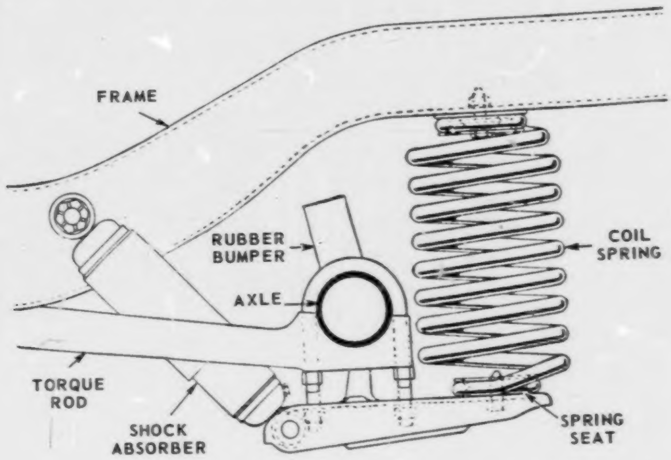

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Figure 4-40.—Coil spring mounting.

figure 4-18. Coil springs are used on a number of passenger cars with torque tube drive.

OPERATOR MAINTENANCE

Under normal operation, and given proper maintenance, suspension systems would not need adjustments or replacement for many miles. The spring assemblies of the suspension system should be checked regularly to ensure that shackles are tight and that bushings within the shackles are not worn excessively or frozen tight. Occasionally, spraying lubricating oil on the spring leaves helps to prevent squeaking at the ends of the spring leaves. Following the lubrication chart furnished for a particular vehicle, check and lubricate the front suspension system including linkage, kingpin, and ball joints. During your checks you may find shock absorber bushings worn; if so, it is best to have the bushings replaced, or in some instances a complete replacement of the shock absorbers is needed.

MALFUNCTION DETECTION

Some types of suspension troubles that may be encountered in vehicle operation are: Hard steering, vehicle wander, vehicle pulls to one side during normal driving, front-wheel shimmy, front-wheel tramp (high speed shimmy), steering kickback, hard or rough ride, sway on turns, spring breakage, sagging springs, and noises. As an operator, you would explain the malfunction on the Operator's Trouble Report and turn the trouble report into the maintenance shop for corrective action.

FRAME

The chassis is the assembly of mechanisms that make up the major operating part of the vehicle (fig. 4-41). It is usually assumed to include everything except the vehicle body. The individual operating assemblies are mounted on the FRAME (fig. 4-42), which must be strong enough to support the weight of the vehicle and its rated load without distortion. The frame must be rigid enough to keep the units of the vehicle in proper alignment and to protect them against the stresses and strains of road and surface shocks.

The frame is generally constructed of cold-rolled open-hearth steel, but sometimes of alloy steel to lighten the weight of the vehicle. The SIDE MEMBERS or RAILS are the heaviest parts of the frame. The CROSS MEMBERS are fixed to the side members rigidly enough to prevent weaving and twisting of the frame. Angular pieces of metal called GUSSET PLATES are riveted or welded at the point where members are joined for added strength.

The number, size, and arrangement of cross members depend on the type of vehicle for

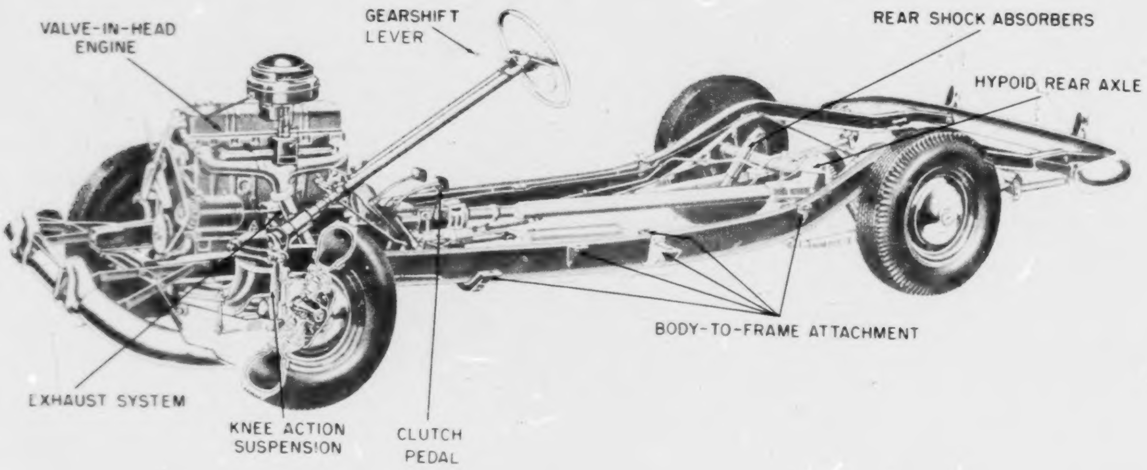

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Figure 4-41.—Chassis of a car.

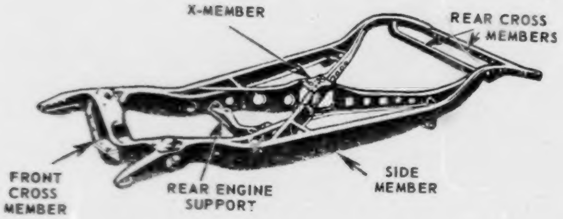

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Figure 4-42.—Passenger car frame.

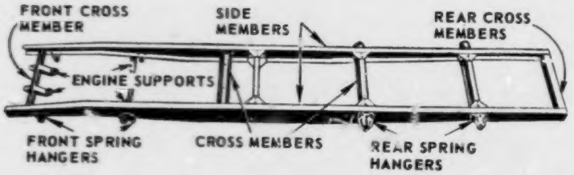

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Figure 4-43.—Truck frame.

which the frame is designed. Usually, a front cross member supports the radiator and front end of the engine as well as stiffens the frame. The rear cross members furnish support for the fuel tanks and rear trunk on passenger cars, and the tow-bar connections for trucks. Additional cross members are added to the frame to support the rear of the engine and power train and to secure the rigidity required.

The cross members of most small vehicles are designed in either X or K form. The front cross members are wider and of heavier construction than the back members because they support the engine and the front wheels. The side members are shaped to accommodate the body and support its weight. They narrow toward the front of the vehicle to permit a shorter turning radius for the wheels and widen under the main part of the body where the body is secured to the frame. Trucks and trailers usually have frames with straight side members to accommodate several designs of bodies and to give the vehicle added strength to withstand heavier loads (fig. 4-43). Heavy duty trucks and trailers have I-beam frames.

Brackets and hangers which are bolted or riveted to the frame to support the shock absorbers, fenders, running boards and springs are usually made of case or pressed steel, depending on the strength required. Spring hangers, subject to twisting and running gear stresses are, in most cases, drop forgings.

Most light-wheeled tractors have no frames. Their running gear, power train, and engines are assembled as a unit. A bracket or detachable framework is fastened to the assembly to provide a seat for the driver. To protect the driver, a canopy is sometimes attached to the assembly instead of a body or cab.

CHAPTER 5

AUTOMOTIVE VEHICLES

As an Equipment Operator, you will be operating passenger vehicles, trucks (cargo or dump), truck-trailer combinations, or fuel handling equipment. This chapter provides general information on starting, operating, and maintaining automotive equipment for hauling materials, equipment, passengers, and fuels. It includes information on the capabilities, gross limits, and utilization of automotive equipment. Also covered are safety precautions to be observed when operating or working near automotive equipment, inflating and changing tires, and handling, loading, hauling, and offloading materials, equipment, and fuels. In addition, information is included on dispatching equipment and the records and reports which must be maintained. A knowledge of the information in this chapter and its application to the job will enable you to perform your duties more efficiently.

TYPES OF AUTOMOTIVE VEHICLES

Automotive vehicles used by the Navy are designed primarily to ensure the performance of necessary tactical and administrative transportation functions under varied conditions. Military requirements generally limit the use of an unmodified commercial-type vehicle to administrative uses, whereas design specifications and performance characteristics of vehicles dictate their capabilities and limitations under various conditions. EOs must recognize these capabilities and limitations to make the most efficient use of the types of vehicles employed by the Navy.

Passenger Carrying Vehicles

The most common types of passenger carrying vehicles are automobiles, buses, carryalls, station wagons, and ambulances. These vehicles are used to transport light cargo and personnel.

Hauling Vehicles

The most common Navy standard trucks are classified by weight-carrying capacity and by body type. The weight-carrying capacity may be referred to as LIGHT trucks, from 1/2 to 2 tons, MEDIUM trucks, from 1-1/2 to 2-1/2 tons, and HEAVY DUTY trucks, from 2-1/2 to 5 tons.

A body-type classification may refer to the principal purpose for which the truck is used (hauling of cargo), or to the physical character of the particular body (stake, van, or dump).

Truck-Tractor and Semitrailer

Besides standard trucks, the Navy uses many truck-tractors with semitrailers. Truck-tractors used to tow semitrailers may be gasoline or diesel engine powered, and range in capacity from 5 tons through 15 tons. Semitrailers are made in a variety of body types such as personnel carrying, fuel tank, cargo van, stake, bitumen tank, and low-bed (equipment hauling). The Navy uses a variety of low-bed trailers of several lengths and widths up to 75-ton capacity.

Fuel Handling Vehicles

Fuel handling vehicles are classified as "fuel tank trucks" or "fuel tank semitrailers." Each vehicle has distinguishing characteristics (model, size, and capacity). The purpose of fuel handling vehicles is to load, haul, and discharge fuel to other vehicles, aircraft, or fuel depots.

WEIGHT DISTRIBUTION AND LOAD SECURING METHODS

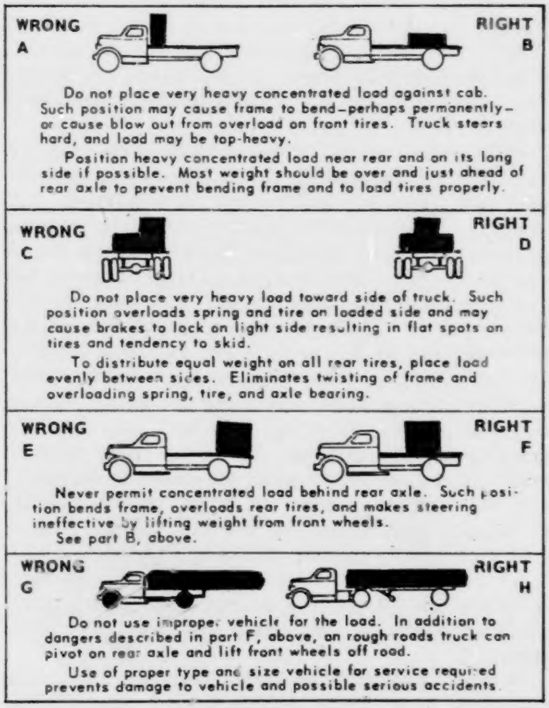
Distribution of cargo has definite bearing on the life of tires, axles, frame, and other parts of the vehicles. The fact that a truck or trailer is not loaded beyond its gross vehicle weight capacity does not mean that the individual tires and axles may not be overloaded by faulty distribution of the cargo. Some examples of proper and improper placement of the load are shown in fig. 5-1.

As an aid to properly loading a truck or semitrailer, the center of the payload must be determined. In a truck, the position of the center of payload is the center of the body, or the point midway between the rear of the driver's cab and the tailgate. In a truck-tractor semitrailer unit, the position of the center of the payload is roughly the center of the semitrailer body, because the tractor's front wheels seldom carry any of the payload. When loading, it is important that the maximum capacity of the vehicle is not exceeded over any one of the axles and, if possible, that loads are distributed so that there is a less-than-maximum axle loading. Examples of approximate distribution of total weight are shown in fig. 5-2. No vehicle will be loaded over its rated capacity without direct authorization.

The trend of vehicle manufacturers is to rate trucks in terms of maximum gross vehicle weight instead of by tonnage capacities. This has resulted in poor utilization of trucks because of loading below rated capacities. It has also caused confusion, in many instances as to the maximum pounds of payload that may be transported in trucks rated in tonnage capacities.

The maximum permissible payload of a truck is determined by deducting the curb weight and weight of the driver (175 lb.) from the manufacturer's gross vehicle weight rating. The maximum gross vehicle weight rating for a specified operating condition applies only when the tires and equipment on the truck are in accordance with the manufacturer's recommendations for the specified operating condition, which is referred to as "ideal," "moderate," or "severe."

IDEAL CONDITIONS mean that the truck is operated over improved, level roads, such as



Do not place very heavy concentrated load against cab. Such position may cause frame to bend—perhaps permanently—or cause blow out from overload on front tires. Truck steers hard, and load may be top-heavy.

Position heavy concentrated load near rear and on its long side if possible. Most weight should be over and just ahead of rear axle to prevent bending frame and to load tires properly.

Do not place very heavy load toward side of truck. Such position overloads spring and tire on loaded side and may cause brakes to lock on light side resulting in flat spots on tires and tendency to skid.

To distribute equal weight on all rear tires, place load evenly between sides. Eliminates twisting of frame and overloading spring, tire, and axle bearing.

Never permit concentrated load behind rear axle. Such position bends frame, overloads rear tires, and makes steering ineffective by lifting weight from front wheels.

See part B, above.

Do not use improper vehicle for the load. In addition to dangers described in part F, above, on rough roads truck can pivot on rear axle and lift front wheels off road.

Use of proper type and size vehicle for service required prevents damage to vehicle and possible serious accidents.

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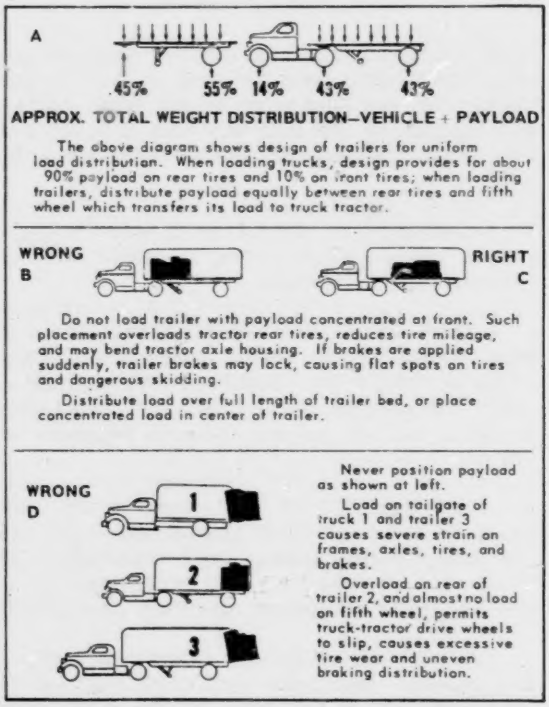
Figure 5-1.—Placement of payload.



The above diagram shows design of trailers for uniform load distribution. When loading trucks, design provides for about 90% payload on rear tires and 10% on front tires; when loading trailers, distribute payload equally between rear tires and fifth wheel which transfers its load to truck tractor.

Do not load trailer with payload concentrated at front. Such placement overloads tractor rear tires, reduces tire mileage, and may bend tractor axle housing. If brakes are applied suddenly, trailer brakes may lock, causing flat spots on tires and dangerous skidding.

Distribute load over full length of trailer bed, or place concentrated load in center of trailer.

Never position payload as shown at left.

Load on tailgate of truck 1 and trailer 3 causes severe strain on frames, axles, tires, and brakes.

Overload on rear of trailer 2, and almost no load on fifth wheel, permits truck-tractor drive wheels to slip, causes excessive tire wear and uneven braking distribution.

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Figure 5-2.—Distribution of total weight.

asphalt or concrete, at constant, relatively moderate, speeds, with no adverse weather or road conditions. Under these conditions, recommended payload equals 100 percent of maximum permissible payload.

MODERATE CONDITIONS mean that the truck is operated at high speeds over improved highways, such as asphalt or concrete, with or without long or steep grades, or at moderate speeds over semi-improved roads with gravel or equivalent surfacing, in gently rolling country with few steep grades and no adverse weather or road conditions. Under these conditions, recommended payload equals 80 percent of maximum permissible payload.

SEVERE CONDITIONS means that the vehicle is operated off the highway on rough or hilly terrain or over unimproved or pioneer access roads with deep ruts, holes, or steep grades; or where traffic has created deep holes or ruts in heavy show covering normally good city streets or highways. Under these conditions, the recommended payload equals 64 percent of maximum permissible payload.

It is important that the payload weight be properly distributed over the body so that the percentage of weight carried by the front axle and that carried by the rear axle will be in the ratio for which the vehicle was designed (See fig. 5-2.)

A knowledge of the following terms will give you a better understanding of payload weight distribution for vehicles.

GROSS VEHICLE WEIGHT (GVW) means the total weight of the loaded truck. It is the sum of the weights of the chassis, accessories, equipment attachments, cab, body, full complement of fuel, lubricants and coolant, payload, and driver.

CURB WEIGHT is the weight of the empty truck—without payload and driver—including fuel tank, cooling system, and crankcase filled. It also includes the weight of tools, spare wheel, and all other equipment specified as standard.

DRY CHASSIS WEIGHT means the weight of the chassis complete with cowl, but not including weight of cab, body or fifth wheel, spare wheel, tire assembly with carrier, fuel, lubricants, coolant, tools, payload, operator, and frame reinforcement where required.

PAYLOAD ALLOWANCE means the maximum weight of material that can be transported.

Check material for damage before and during the loading operation. Do not accept damaged material unless the damage is noted on the dispatch order or written acknowledgment of the damage is received from the supply department.

Physical dimensions, capacities, weight limitations, and load distribution of trucks and trailers vary greatly. These variations preclude the covering of all types of loads. Therefore, the methods and procedures described here must be considered typical.

There are conditions which can cause load movement while in transit. However, almost all load movement can be prevented by proper blocking and bracing. All loads must be balanced in the vehicle lengthwise and crosswise before the vehicle is operated. Precautions must be taken to prevent vertical movement because of sudden stops or travel over rough terrain as vertical movement can cause the breakdown of good blocking and bracing. If the load is not placed tightly or is out of alinement, the unbalanced loading will cause unequal pressures. The use of bulkheads, separation gates, dividers (lengthwise and crosswise), layer separations, runners, blocks, cleats, and strapping, properly fabricated and applied, will prevent most load movement.

The truck and trailer combination can be adapted to transport various types of materials such as fragile, bulky, compact, dense and rough items, and high center of gravity items. In order to accommodate the variety of items you must plan the load, properly prepare the truck or trailer, and secure the load to the vehicle. This will prevent any possibility of the load shifting or falling off the vehicle, shifting and contacting other traffic, fouling underpasses, culverts, bridge abutments, and creating a hazard to pedestrians. Securing the load can be accomplished by staying the load with proper lines, or chains secured by tie-down or binders. Use appropriate gear such as paper, cloth, or other type filler to protect fragile items from damage by chafing (rubbing together).

If the truck or trailer is not enclosed or covered, use tarpaulins to cover the cargo and prevent exposure, damage, loss of cargo, or littering.

When transporting pipe, lumber, or other unusually long loads which extend beyond the truck body, attach a red flag to the end of the load and use a red light to mark the end of the load when traveling at night. (See fig. 5-3.)

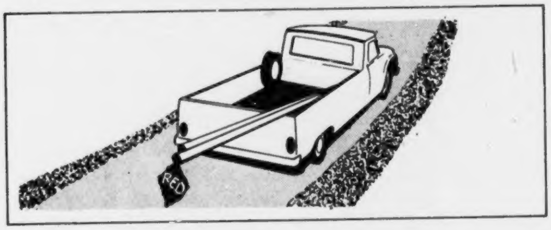

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Figure 5-3.—Warning (red flag) of extended load.

Before operating a truck or trailer loaded with unusually heavy, long, or odd-sized materials, ensure that the load weight and dimensions are within the prescribed state and local regulations. If oversize or overweight vehicles are required to be used for a particular job, obtain special permits prior to moving such loads or vehicles on public highways.

When transporting explosives or material interstate, adhere to all military instructions, state and local laws, and I.C.C. regulations described in chapter 10 of this manual.

PRINCIPLES OF OPERATION OF PASSENGER CARRYING VEHICLES

In chapter 4, you learned how components are assembled to make up the automotive chassis, consisting of the engine, frame, power train, wheels, steering and braking systems.

Passenger carrying vehicles which include automobiles, buses, carry alls, station wagons, and ambulances are all similar in their principles of operation although some assemblies and components will be different in body styles, types, and sizes.

PRINCIPLES OF OPERATION OF HAULING VEHICLES

A typical military-type DUMP truck is equipped with a dump body which has a struck capacity of 5 cubic yards, and is hinged to the rear of a subframe which is mounted directly on the truck chassis. The hoist assembly used to raise and lower the dump body is comprised of a pair of double-acting hydraulic cylinders, a positive-displacement gear-type hydraulic pump, a hydraulic oil reservoir, and connecting high pressure-type hoses. The hydraulic pump is driven by a propeller shaft connected to the power-take-off. Operation of the hoist assembly is controlled by the dump body control lever located to the left of the driver's seat. (See fig. 5-19.)

By disengaging the vehicle clutch and shifting the dump body control lever to either position other than NEUTRAL, the power-take-off and hoist pump engages. When moving the control lever to the POWER-UP position and engaging the clutch, the dump body will raise (when the dump body reaches its limit of travel, it automatically stops). Upon moving the control lever to the POWER-DOWN position, the dump body will lower. Moving the control level to the NEUTRAL position and locking it will secure the dump body.

Another hauling vehicle used by the Navy is the TRUCK-TRACTOR and SEMITRAILER combination. This combination is unique in the manner in which the semitrailer and truck-tractor are attached to perform the hauling services for which they are intended. A large part of the weight of the semitrailer in this combination is supported by a connection, called the FIFTH WHEEL (fig. 5-4), the remaining weight is supported by the wheels of the semitrailer. The trailer braking system (usually air) is coupled to the towing vehicle by a flexible hose and a detachable coupling fig. 5-5). The trailer braking system is usually designed so that it will keep the trailer in place when the couplings are disconnected. The trailer is also equipped with a landing gear which is a retractable support under the front end of the semitrailer. This gear is used to hold up the front end when it is uncoupled from the truck-tractor. When semitrailers are coupled and uncoupled, it is important that operation of the landing gear be coordinated with operation of the fifth wheel lock. If the landing gear is elevated before the fifth wheel connection is fully locked, the front end of the semitrailer will drop to the ground when the truck-tractor is driven away, with the possibilty of damaging both the load and the semitrailer. Before the semitrailer is uncoupled, the brake couplings should be disconnected so that the semitrailer brakes are applied to prevent it from moving.

The method of connecting the truck-tractor to the semitrailer is by means of a fifth wheel. The upper fifth wheel plate (fig. 5-4) is securely attached to the underside of the front end of the semitrailer frame. Permanently attached to the center of the upper fifth wheel plate is a kingpin by which the truck-tractor pulls the

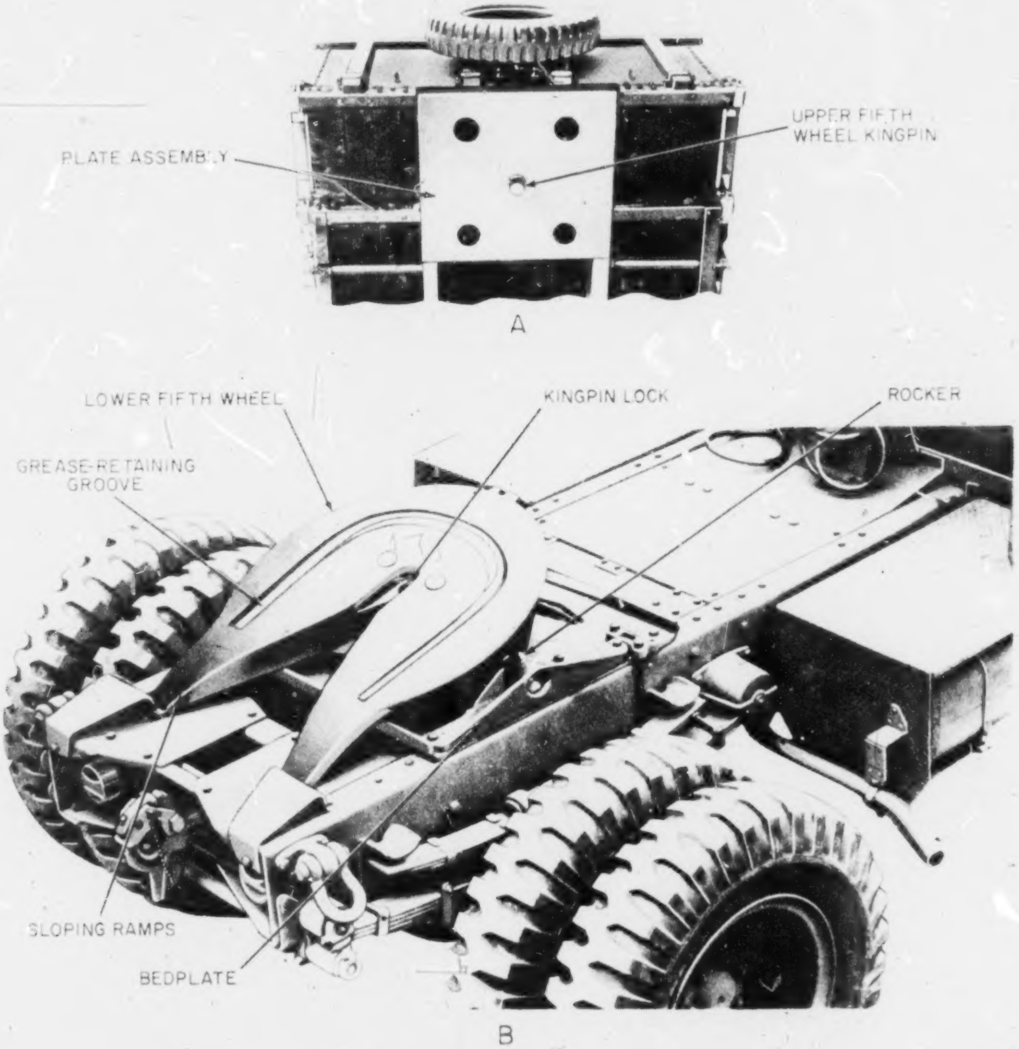

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Figure 5-4.— Truck-tractor and semitrailer connections.

semitrailer after the upper fifth wheel is attached to the truck-tractor lower fifth wheel (fig. 5-4). The kingpin is locked into position by a kingpin lock which is a ring on the lower fifth wheel that clamps around this kingpin. The kingpin lock is operated by a hand lever that extends to the side of the lower fifth wheel and can be released by pulling it out when the semitrailer is to become detached from the truck-tractor.

PRINCIPLES OF OPERATION OF FUEL HAULING VEHICLES

A typical FUEL TANK truck is equipped with a tank body divided into compartments. Each compartment has a manhole and filler cover assembly, bottom sump or well, discharge valves with screen assemblies and drainpipe. The drainpipes end in a manifold in the equipment compartment. The compartment (fig. 5-6) also houses

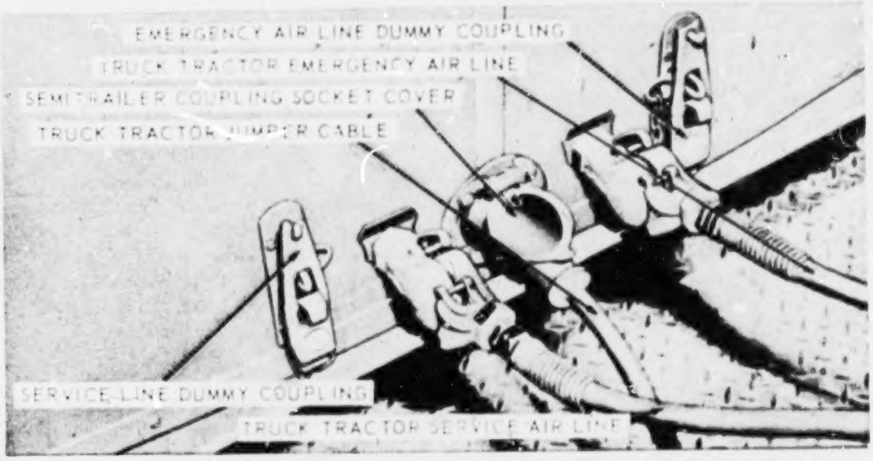
EMERGENCY AIR LINE DUMMY COUPLING
TRUCK TRACTOR EMERGENCY AIR LINE
SEMITRAILER COUPLING SOCKET COVER
TRUCK TRACTOR JUMPER CABLE
SERVICE LINE DUMMY COUPLING
TRUCK TRACTOR SERVICE AIR LINE

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Figure 5-5.—Brake line and trailer-light connections.

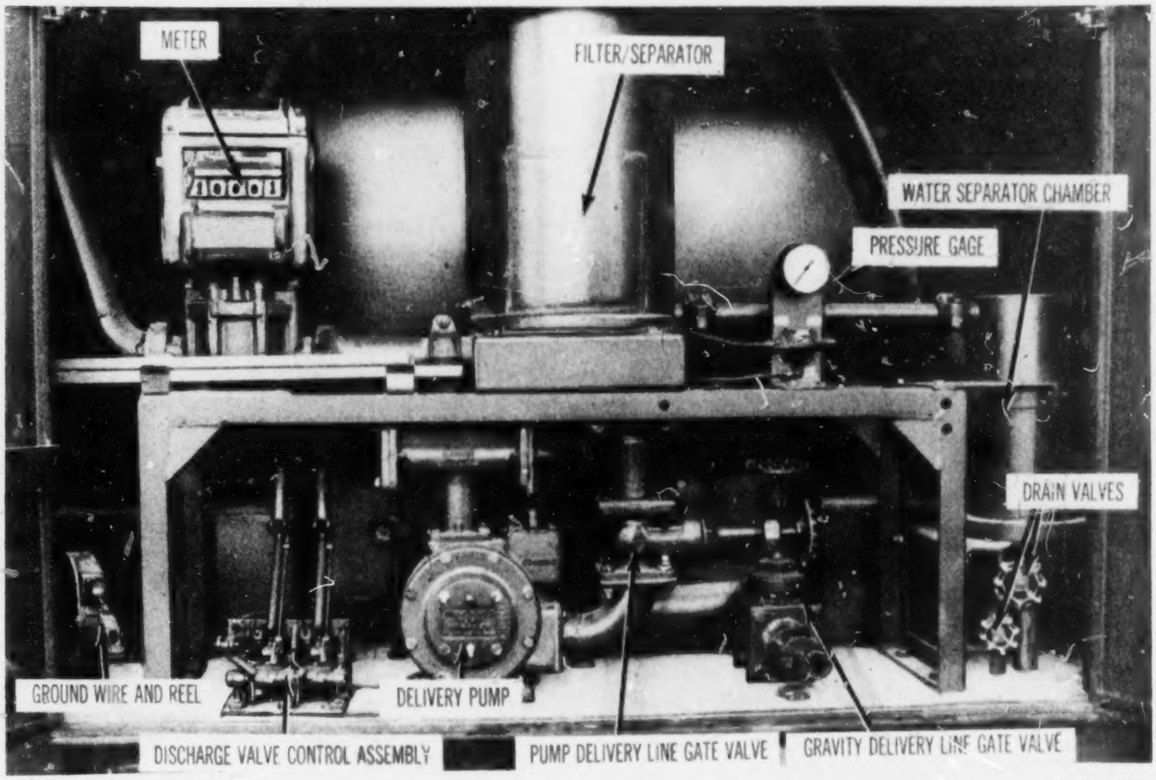

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Figure 5-6.—Rear equipment compartment of a tank truck.

a delivery pump, a discharge valve control assembly, a pump delivery line gate valve, automatic dump valve drain tube valves, a gravity line gate valve, a filter separator, a pressure gate, a meter, a water separate chamber, and a grounding cable.

The delivery pump is powered by the transfer power takeoff, which is controlled by the transfer power shifting lever located in the driver's compartment. The lever is moved backward to the ENGAGED position to engage the power takeoff which causes the pump to operate. The lever is moved forward to the DISENGAGED position to disengage the power takeoff and stop the pump.

The discharge valve control operating levers control the discharge valves located at the bottom of each tank compartment. Pulling back on a lever opens a discharge valve and permits the flow of fuel into the piping system. Squeezing the trip rod operating handle mounted on the lever, and moving the lever forward, locks the compartment valve and shuts off the flow of fuel.

In an emergency, the discharge valve control remote control lever, located on the left side of the discharge valve control operating lever bank, provides a means of locking all discharge valves. Pulling the handle causes a release lever to trip the operating levers and locks the valves.

AUTOMOTIVE VEHICLE OPERATION

The sole source of complete and authentic information on operating a given automotive vehicle is the operator's manual issued by the manufacturer.

The information given in this section describes the prestart checks, starting checks, and operating procedures which are typical of automotive vehicles used by the Navy.

PRESTART CHECKS

Before operating any vehicle be sure that it is ready for the run. A prestart check should begin as you approach your vehicle. Take a look at it. Does its overall appearance seem normal? Oftentimes you will be able to tell from this first look if your vehicle has a broken spring or other exterior defects.

As you continue with the prestart check, move around to the front of your vehicle and raise the hood. Check the coolant by removing the radiator cap. If the coolant level is not visible, add coolant. Continual lowering of the level of coolant indicates a possible leak in the cooling system. In freezing weather, test the antifreeze solution in the radiator with a hydrometer. If necessary add enough antifreeze to the coolant to prevent freezing at predicted minimum temperatures. Be sure to report a leaking cooling system on the Operator's Trouble Report so that corrective action can be taken by the maintenance shop.

Next check the level of the lubricating oil in the crankcase. It should be at or near the FULL mark on the dip stick. If it is not, add sufficient oil to raise the level to FULL. If the oil is dirty and gritty when rubbed between the finger tips, it will have to be changed.

Fan belts should be checked for defects in the belt, and excessive looseness or tightness. When found to be defective the belts must be replaced. When found to be too loose or too tight, adjust according to the manufacturer's specifications. (See fig. 5-27.)

Battery water level must be checked. If the level is not visible, add battery water to the level required. Check for loose battery wire connections, and tighten if required. Have worn or frayed battery wires replaced by the maintenance shop.

Close the hood, making sure that it latches properly.

Check the fuel tank. Most fuel tank gages register when the ignition switch is turned on. If the fuel gage is not working properly, and you have no way of knowing how much fuel is in the tank, fill it up. Running out of fuel could be very inconvenient and embarassing. Be sure to report improper operation of the fuel gage on the Operator's Trouble Report, so that corrective action can be taken by the maintenance shop.

Leaks found during your checks, can often be corrected by tightening bolts, filler plugs, and line connections. If these steps fail to stop a leak, report the trouble for corrective action by the maintenance shop.

As you check the wheels and tires, be sure the tire pressure is as recommended (usually stenciled on each fender of the vehicle) by using either a tire gage or a tire air-hose that is equipped with a gage. Be particularly alert for uneven tread wear; this condition may indicate misalignment, need for balancing, or improper inflation. You may replace the tire at the tire shop, but balancing or alignment will be handled by the maintenance shop. When inspecting the wheels, see that the wheel flange bolts are in place and properly secured.

As you continue your prestart checks, examine the vehicle body for missing components, doors that close improperly, any door windows and windshield glass that are cracked or broken. Next look under the vehicle to check the drive shaft, rear end, and rear axles for leaks or other obvious defects. Any discrepancies must be reported on the Operator's Trouble Report, so that corrective action can be taken by the maintenance shop.

When you have completed the external portion of the prestart checks, get into the cab and check the lights by turning on the light switch and observing whether the headlights are burning on both high and low beam. Have someone observe whether the stoplights on the rear of the vehicle go on when you apply the brakes. As you inspect the lights, wipe the glass lenses with a cloth. A film of mud or dust can cut light beams considerably. If the vehicle has special lights, such as turn signals, fog lights, and spotlights, they, too, must be in good working condition. Test the horn, check seat belts, and inspect the rear view mirror for damage. Before moving on, check the condition of the windshield wiper blades. In addition; check the vehicle's brakes, making sure that the brake lines are not broken or leaking, and that the parking brake cable and assembly are in working order. If any item needs to be adjusted, repaired, or replaced, note the trouble on the Operator's Trouble Report, so that corrective action can be performed by the maintenance shop.

A prestart check will be slightly different for each type vehicle, but the basic principles apply to all. At first, these checks may seem like a long and useless procedure. Once you have established a routine, however, you will find that the complete check requires only a few minutes. Many times this check will save you hours of trouble in the field or on the road.

Make sure that an Operator's Report of Motor Vehicle Accident, Standard Form 91 and an Accident-Identification Card, DD Form 518 are in the vehicle; also be certain that you have a currently dated Vehicle/Equipment Request and Report, NAVFAC 9-11240/1 that authorizes you to use the vehicle, and an Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13 that is to be filled out in case of trouble.

STARTING CHECKS BEFORE OPERATION

After starting the engine, but before putting the vehicle or equipment into motion, make a few additional checks. First, and most important, make certain that you get an oil pressure indication. This indication may be below operating range at first, but be certain that it is registering. If your equipment has an oil pressure low warning light, make certain the light does not remain on more than several seconds after the engine is started. If the light does not go out after several seconds of engine operation, stop the engine and call a mechanic. Occasionally, a defective system causes the light to stay on, but in either case you will need the mechanic.

Your vehicle or equipment ammeter should also register a positive charge as the engine starts to run. This may be indicated by an ammeter which begins to register in a positive direction or by a red light which goes out when the charging begins. You should also check the temperature indicator, which should start to move upward on its scales as the engine warms up. In addition, check the windshield wipers to see if they are operating properly.

DURING OPERATIONS CHECKS

When a vehicle or piece of equipment is not operating properly, there are various symptoms by which the malfunction can be identified. You should be able to recognize these symptoms immediately and stop the machine before damage results. We have already mentioned the starting checks for oil pressure and the electrical system. Now let's look at some of the troubles that may occur during operation.

Temperature

The operating temperature of your piece of equipment is a measure of its mechanical condition. An engine that is running too hot or too cold is not functioning properly, and the cause of the high or low temperature should be determined immediately. If there is trouble in the cooling system the engine, in most cases, will overheat.

Before you run your piece of equipment into the repair shop or call a mechanic, make a few checks to see if you can locate the trouble. First, check the radiator. If the water is low, refill. In addition, check to see if there are leaves or other matter clogging air passages of the radiator grill. Check the oil level. An insufficient amount of oil can cause overheating. Loose, slipping water pump belts and fan belts will cause overheating; check and tighten them if they are slipping.

If you eliminate these possible causes of overheating, and the temperature is still not normal, it is time to call a mechanic.

Oil Pressure

As mentioned earlier you should make certain that oil pressure registers when the engine is started. High pressure readings may be observed while the engine is warming up in cold weather, before the oil has reached operating temperature. After a brief warmup period, the gage indicator should return to normal. Do not forget, however, to keep constant check on oil pressure throughout the day. If the pressure should drop, STOP THE ENGINE and notify a mechanic.

There are a number of things that can cause low oil pressure. Diluted lubricating oil will cause a drop in pressure. If the oil is at the proper level, but is thin and lacks body, it may have been diluted with fuel leaking past the piston rings. The crankcase should be drained and refilled with the proper grade of oil. If frequent oil dilution or low oil pressure continues after changing the oil, your engine needs further services of a mechanic. As mentioned before, on rare occasions the trouble will be in the pressure gage rather than in the engine proper.

Electrical System

If your piece of equipment has a generator and battery, the ammeter indicates the condition of the electrical system. If the ammeter shows a discharge when the engine is running and all electrical accessories such as lights have been turned off, there is something wrong with the system; call a mechanic. Some vehicles have a warning light instead of an ammeter; if this light comes on and stays on during engine operation (except when the engine is idling), this too is an indication of trouble in the electrical system.

Smoking

Whenever you are operating motorized equipment and you see smoke coming from the exhaust pipe, there is trouble of some sort. The most common causes of smoking in a gasoline engine are worn pistons, rings, or cylinders, and faulty fuel mixtures. Smoking caused by worn engine parts is usually coupled with high oil consumption and calls for a major overhaul.

There are a number of mechanical troubles that will cause a diesel to smoke. If the engine is running too cool, the exhaust will form a cloud of white smoke. If the radiator is equipped with adjustable shutters, close them until the engine reaches the proper operating temperature. If the engine does not have shutters, place a partial covering over the radiator to bring the temperature up. Another cause of smoky exhaust is a clogged air cleaner. Follow the maintenance instructions printed on the air cleaner.

If the engine is allowed to idle for considerable periods, there will be more fuel injected into the cylinder than will burn, and consequently it will smoke. Do not idle the engine for long periods.

If the engine is subjected to loads that cause it to slow or lug down, it will begin to smoke. The remedy is to keep the engine revved up and to use the proper gear to handle the load. If you eliminate these causes of smoking and the engine still smokes, it is probably due to injectors, valves, fuel pumps, or worn piston rings; any of these conditions means a repair job for the mechanics.

Wheel Trouble

If you are operating automotive equipment, your hands on the steering wheel will tell you if the vehicle pulls to the right or to the left. You will feel vibrations caused by unbalanced wheels. When you apply the brakes, you will be able to feel whether the wheel is pulled to the right or to the left; thus you will know whether the front wheel brakes are operating evenly.

When you feel the vehicle pull to one side, stop and check the tires. If the tires are evenly inflated and the vehicle still pulls to one side, you should have the wheel alignment and the wheels checked by a mechanic. Your hands on the wheel will also tell you if the vehicle turns hard and whether the play in the steering wheel is excessive.

Transmission and Differential

Transmission difficulties may be characterized by shifting difficulty, gears jamming, and by unusual noises from the area where the transmission is located. This is true of a vehicle having either a manual or an automatic transmission. About the only thing that an Equipment Operator can do is to check the level of lubricant; if the transmission is low on lubricant, fill it to the proper level.

Differential trouble can often be recognized by noise from the differential area. However, noise from defective universal joints, rear-wheel bearings, tires, or mufflers are sometimes mistaken for differential trouble. Stop the vehicle if noise occurs. For the purpose of operational maintenance with respect to differentials, an Equipment Operator has the responsibility of seeing that lubricant is at the proper level and bringing it up to the proper level if it is low. If there is differential trouble and you find that the level is not low, you should turn the job of locating and correcting the trouble over to a mechanic.

Brake Troubles

If your equipment is fitted with airbrakes, be aware of the air pressure indicator reading at all times. The reading may be too high; a high reading would probably indicate a faulty air gage, a governor out of adjustment, or a defective governor. The most usual trouble with airbrakes is too little pressure. Low pressure can indicate a number of things, but most commonly it indicates a defective air safety valve, a governor out of adjustment, or an excessively worn compressor.

The air pressure gage is only one of the possible means by which you will discover trouble. Some of the other airbrake troubles are that they release too slowly, grab, or brake unevenly.

On hydraulic brakes, a soft, spongy pedal indicates either improper adjustment or air in the system. A pedal that goes to, or nearly to, the floorboard calls for immediate attention by a mechanic. Stops that require excessive pressure on the pedal, and brakes that are overly sensitive and grab when only slight pressure is applied to the pedal are other troubles that mean work for the mechanic.

Be sure that your brakes are in the best possible condition; your life may depend on them.

Clutches

If the clutch does not completely disengage when the pedal is entirely depressed or if the clutch takes hold too near the floorboard, you should report the condition to a mechanic.

Vibration

On most of the equipment you operate, you will feel a certain amount of vibration; an unusual amount of vibration should not have to shake you out of your seat to make you realize that something is wrong. Unbalanced wheels, a cylinder that is not firing, a bent drive shaft, and other mechanical defects will cause excessive vibration.

After operating a piece of equipment for a period of time, you should be so aware of its characteristic sounds and its feel that you will be able to detect the slightest variation from normal operation. You may not be able to diagnose the mechanical symptoms, but you should be able to recognize trouble when it starts.

OPERATING PASSENGER CARRYING AND HAULING VEHICLES

After completing all prestarting and starting checks, and ensuring everything is in order, place the transmission in NEUTRAL or PARK and start the engine (fig. 5-7). Before you pull onto the road, be sure that it is clear enough for you to do so safely.

If your vehicle has an automatic transmission, set the transmission lever at D (DRIVE) or push in the D button (fig. 5-7). Release the emergency brake and speed up the engine by depressing the accelerator about one quarter of the way toward the floor board. The vehicle should accelerate in LOW smoothly. At a speed of about 18 to 25 mph under normal acceleration the transmission should shift automatically into DRIVE. On some vehicles you must release the accelerator momentarily to let the transmission shift into DRIVE. A faint click in the transmission indicates the shift to the higher gear.

With a standard transmission, depress the clutch pedal, shift into first (low) gear, release

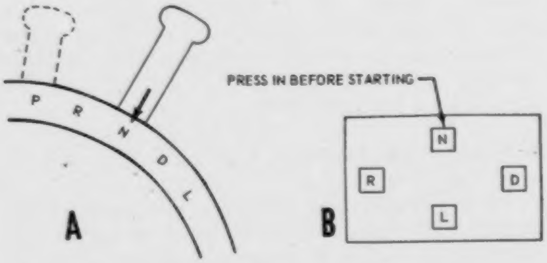

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Figure 5-7.—Gears must be in NEUTRAL or PARK before starting.

the emergency brake, and engage the clutch slowly and smoothly while speeding up the engine a bit with the accelerator. Let the vehicle get up to about 10 to 15 mph before shifting into second gear, and to about 20 to 25 mph before shifting into third or high gear. Depress the clutch pedal before each shift, and release it smoothly after shifting.

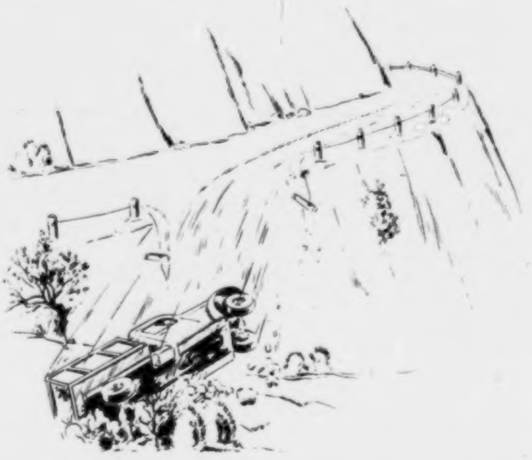
On many vehicles with standard transmission the gear shift lever is mounted on the steering column. Refer to the vehicle instruction manual for gear shifting directions.

Up and Down Grade

In starting a vehicle with a standard transmission up a grade from a stationary position, keep the emergency brake on to prevent the vehicle from rolling backward. Push in the clutch, shift into low, then ease off on the clutch pedal. As the clutch begins to take hold, release the emergency brake slowly, AT THE SAME TIME increasing the speed of the engine. If these operations are performed carefully, the vehicle should start smoothly. Shift the vehicle into second only when it has reached enough speed to continue upgrade without laboring or jerking. You may not be able to shift from second to high until the end of the grade. If the grade is very steep, you may have to use low gear all the way up.

Downgrade always use the same gear that would be used going upgrade. Depress the clutch, shift into neutral, accelerate the engine to a speed that will pull the vehicle in a lower gear, then shift into the lower gear. If the procedure is efficiently carried out, the shift will be virtually noiseless.

UNDER NO CIRCUMSTANCES SHOULD THE VEHICLE COAST DOWNGRADE IN NEUTRAL. A vehicle out of gear is out of control except, possibly, when the brakes are applied. Even then the vehicle may pick up speed in excess of its braking ability, and you risk not only burning up the brakes, but having a serious accident as well (fig. 5-8).



115.37
Figure 5-8. — Out of gear, out of control.

Low Range and Double-Clutching

Heavy trucks may be equipped also with a two-speed rear axle and have what is known as a LOW RANGE. By shifting to this low range, you tap the extra engine power that is needed to start an extremely heavy load, in rough driving, and in steep climbing. Under normal driving conditions you would use the normal range.

No matter what kind of load the truck is carrying, start out in low gear, not in second. Together, the low range and low gear give maximum starting power. Take your time and accelerate smoothly in each gear before shifting to the next higher gear. Under some road or load conditions, the series of shifts from low to high may require as much as a mile of travel (fig. 5-9).

The transmissions of some trucks and buses are constructed in a form which makes it necessary to DOUBLE-CLUTCH to prevent the clashing and grinding of gears when shifting. Double-clutching adjusts engine speed to vehicle speed in a particular gear. Figures 5-10 and 5-11 give brief directions for double-clutching from one gear to another.

Double-clutching requires some practice. If you can possibly arrange to do so, take a truck around a given area with a supervisor or other experienced Equipment Operator to instruct you.

Steering

Proper steering is a matter of keeping your hands on the wheel, your eyes on the road, and your mind on safe driving. It also means keeping the vehicle on your side of the road, avoiding holes and obstructions, and passing other vehicles safely.

If your vehicle steers hard, pulls to the right or left, or the front wheels shimmy, try

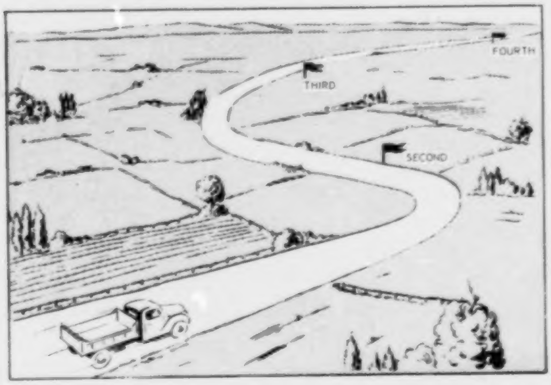


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Figure 5-9.—Take your time.

to find the cause of the trouble at once. It may be due to nothing more than underinflated tires, or it may be caused by the wheels being out of balance or alignment. It may also mean that some part of the steering mechanism needs adjusting, or repair.

If not accustomed to power-steering, you may have difficulty at first in guiding this type of vehicle, because its steering mechanism responds more readily than one with conventional steering. Under power-steering a mere finger nudge of the steering wheel will turn the vehicle from its path.

DOUBLE-CLUTCHING FROM A LOWER TO A HIGHER GEAR

- Push in clutch pedal
- Take foot off gas pedal
- Shift into neutral
- Let out clutch pedal
- Wait momentarily
- Push in clutch pedal again
- Shift to higher gear
- Let out clutch pedal
- Depress gas pedal

115.40

Figure 5-10.—Double-clutching from lower to higher gear.

DOUBLE-CLUTCHING FROM A HIGHER TO A LOWER GEAR

- Push in clutch pedal
- Take foot off gas pedal
- Shift into neutral
- Let out clutch pedal
- Accelerate engine
- Push in clutch pedal again
- Shift to lower gear
- Let out clutch pedal
- Depress gas pedal

115.41

Figure 5-11.—Double-clutching from higher to lower gears.

BACKING.—Not all driving is forward. You will also have to back into loading platforms and parking spaces and into position for shovel loading and other jobs on construction projects. Backing must be done with skill and caution. If the rear view of your vehicle is restricted, have someone direct you. Otherwise, get out frequently to check whether the way is clear. NOTE: The operator is responsible for all backing accidents.

CURVES.—Speeding under any conditions is dangerous and unsafe, but speeding on curves is extremely dangerous for at least four reasons: it increases the hazard of skidding; it heightens the possibility of load shifting; it wears tires away very fast; and the vehicle may run off the road or overturn.

It is not easy to state at what speed you can SAFELY round a curve. The maximum safe speed depends on the arc of the curve, the width of the road, and the condition of its surface. Many curves are posted with safe speed limit signs, but on many, YOU still must judge how fast to take them.

In approaching a curve, SLOW DOWN as soon as it comes into view, then accelerate enough to keep the vehicle pulling steadily. If the road ahead curves frequently, maintain a speed moderate enough to keep the vehicle on an even keel, using the highest gear possible. Avoid using the brakes. NEVER try to pass another vehicle on a curve. Stay on your own side of the center line.

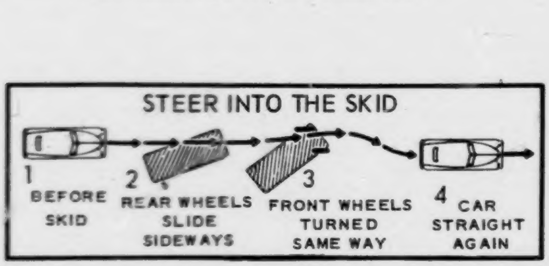
SKIDS.—To avoid skids watch for obstructions, pavement breaks, holes, shoulder edges, and loose gravel that might grab your wheels. Beware of wet roads, roads strewn with leaves, roads full of mud or slush, and railroad and trolley tracks.

To prevent going into a skid, cut down your speed, and increase the distance between your vehicle and the one ahead. Do not accelerate too fast or the wheels may spin; drive in as high a gear as possible. The higher the gear, the less the tendency to skid. Should you get into a skid, however, turn the wheels IN THE DIRECTION OF THE SKID, stay in gear with the clutch engaged, and accelerate slightly to help straighten the course of the vehicle. DO NOT APPLY THE BRAKES; you will only increase the skid by locking the wheels. If any slowing is necessary, it should be done in a lower gear. Figure 5-12 illustrates the method of steering out of a skid.

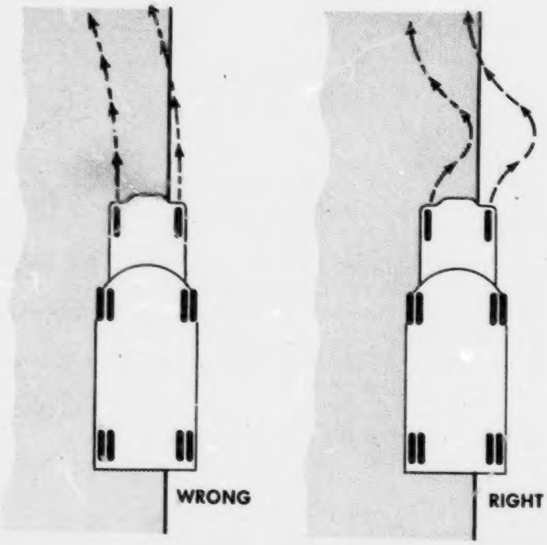
OFF AND ON THE SHOULDER.—Getting off on the shoulder is a common occurrence on narrow roads and in congested traffic, and it usually is not difficult to get back on the road. However, if the shoulder is lower than the road, first, change to a lower gear without braking. Second, instead of scrapping or tearing away the side walls of your tires by trying to creep back upon the road gradually, proceed slowly until you are able to get back by making a sharp angle turn to the left. (See fig. 5-13.)

OPERATING TRUCK TRACTOR AND SEMITRAILER

Before setting out with a truck tractor and semitrailer, you must know the procedures for coupling and uncoupling the truck tractor from the semitrailer. To couple the truck tractor to the semitrailer, proceed as follows:



115.42
Figure 5-12.—Steering out of a skid.



115.44
Figure 5-13.—The right way to get back on the road.

1. Place wheel chocks in front of and behind the trailer wheels.

2. Make sure the fifth wheel lock is open; then back the tractor close enough to the trailer to permit coupling of the brake lines. (See fig. 5-5.)

3. Connect the brake hoses in the proper order by first connecting the turck tractor SERVICE air line hose to the trailer, followed by the EMERGENCY air line hose (fig. 5-5).

4. Open the cutout valve to allow pressure to build up in the reserve tank on the trailer.

5. Apply pressure to the trailer brakes, if they are operated independently. If the trailer brakes are not operated independently, proceed as described below.

a. For vacuum-operated brakes, turn off the service line valve and disconnect the hose; this should automatically apply pressure to the trailer brakes.

b. For air operated brakes, turn off the emergency line valve and disconnect the hose; this should automatically apply pressure to the trailer brakes.

6. Back the tractor under the trailer until the fifth wheel engages the trailer kingpin and locks (fig. 5-4). If the tractor is not in line to

engage the trailer kingpin and must be repositioned, uncoupled the airhose before moving the tractor to avoid breaking the hose.

7. When the fifth wheel and the kingpin are locked, test security of the hookup. Remove the chocks, place the tractor in first gear, engage the clutch, and move the tractor forward slightly while applying pressure to the brakes.

8. If the trailer is properly connected, stop the tractor and set the handbrake; double check all couplings, reconnect the airbrake hose, and open the air valve.

9. Connect the trailer electrical powerline; check for proper operation of lights (fig. 5-5) and, where applicable, heating or refrigeration equipment.

10. Raise the trailer parking legs, and release the trailer parking brake.

11. Before moving the tractor, check the brakes for proper functioning and for adequate air pressure, minimum operating air pressure is 60 pounds.

To uncouple a truck tractor from a semitrailer, proceed as follows:

1. Set the tractor handbrake
2. Apply pressure to the trailer brakes by disconnecting the hose lines, as described above, step (5).
3. Disconnect the trailer electrical powerlines and secure them to the tractor.
4. Place wheel chocks in front of and behind the trailer wheels and set the trailer parking brake.
5. Lower trailer parking legs; be sure the ground is firm enough to prevent the parking legs from sinking.
6. Place the fifth wheel hook lock handle in the release position; move the tractor forward slightly, leaving the trailer kingpin partly in the fifth wheel slot.
7. Recheck the trailer supports; if trailer is secure, move the tractor away from the trailer.

Safe Operation

In driving a tractor-trailer, watch for obstructions. Since a trailer body is often considerably higher than a truck body, you must allow for this height and watch out for viaducts, tree limbs, extended roofs OVER loading docks, and other obstructions. Also watch weight limitations on bridges. A tractor-trailer usually is longer than a truck; therefore, you must drive it carefully to avoid cutting in on other motorists.

Braking, Stopping, and Parking

With independently operated trailer brakes, apply the trailer brakes FIRST, gradually and smoothly, to avoid locking the wheels and skidding. As speed is reduced, apply the truck or tractor brakes to spread the braking load on all wheels. With synchronized brakes both tractor and trailer brakes are operated by one foot pedal like the brakes on automobiles.

In making emergency stops, be sure the trailer brakes are applied either first or simultaneously with—never after—the tractor brakes. Attempting to stop without using the trailer brakes will cause the trailer load to push the tractor forward, and possibly push it into whatever you are trying to avoid. (See fig. 5-14.)

In the event of any stop where you leave your cab, set your parking brake. This applies to all automotive equipment. If you have operated tractor-trailer units, you know that you can hold the unit on a grade by setting the trailer brake. Holding your rig on the grade by setting the trailer brake is all right as LONG AS YOU ARE IN THE CAB, but DON'T set the trailer brake and LEAVE the cab. The engine on your rig may die and cause the air pressure to drop off. If this happens your trailer brakes will release, and you will have a runaway rig.

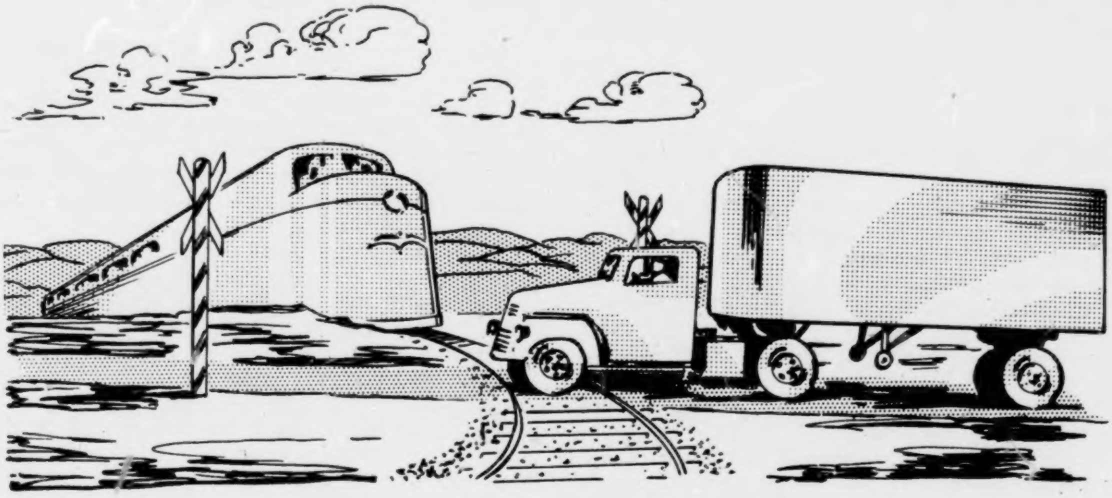
Turning and Backing

In turning a tractor-trailer, remember that the outside turning circle of the complete unit is the same as that of the tractor, and that the trailer wheels cut inside the path of the tractor (fig. 5-15).

At first it might seem that backing would be a difficult operation. Actually, the hinged-in-the-middle feature of tractor-trailer units makes them easier to handle in cramped quarters than conventional trucks.

If you wish to back your automobile or truck to the right, you would naturally turn the steering wheel to the right (fig. 5-16A). To back your semitrailer to the right, you turn your steering wheel to the left. This action pushes the front of the semitrailer to the left and steers the semitrailer wheels to the right, as shown in fig. 5-16B.

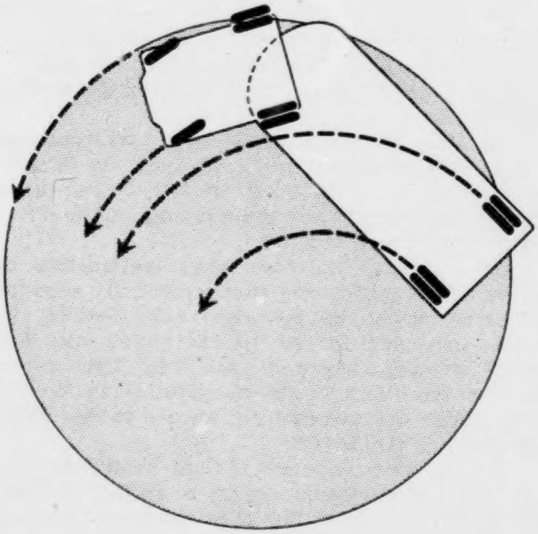
If you have to make a right-hand back into an alley (sometimes called a BLIND BACK), drive the unit past the alley entrance, keeping it far enough from the curb so that the tractor can head slightly to the right as you come to a stop. (See fig. 5-17A.)



115.46

Figure 5-14.—The heavy load may push the tractor ahead.

Before you start to back, check behind the trailer from both sides of the cab to be sure of your distance, and that traffic is clear. Turn the steering wheel to the LEFT to push the semitrailer around and back it to the right as shown in fig. 5-17B. As you continue to back slowly, keep the tractor wheels turned to the left and continue to check clearances from the right-hand door of the cab. As the trailer swings into the alley (with clearance on all sides), turn the steering wheel to the RIGHT and continue to back the semitrailer into the alley as shown in fig. 5-17C.



115.47

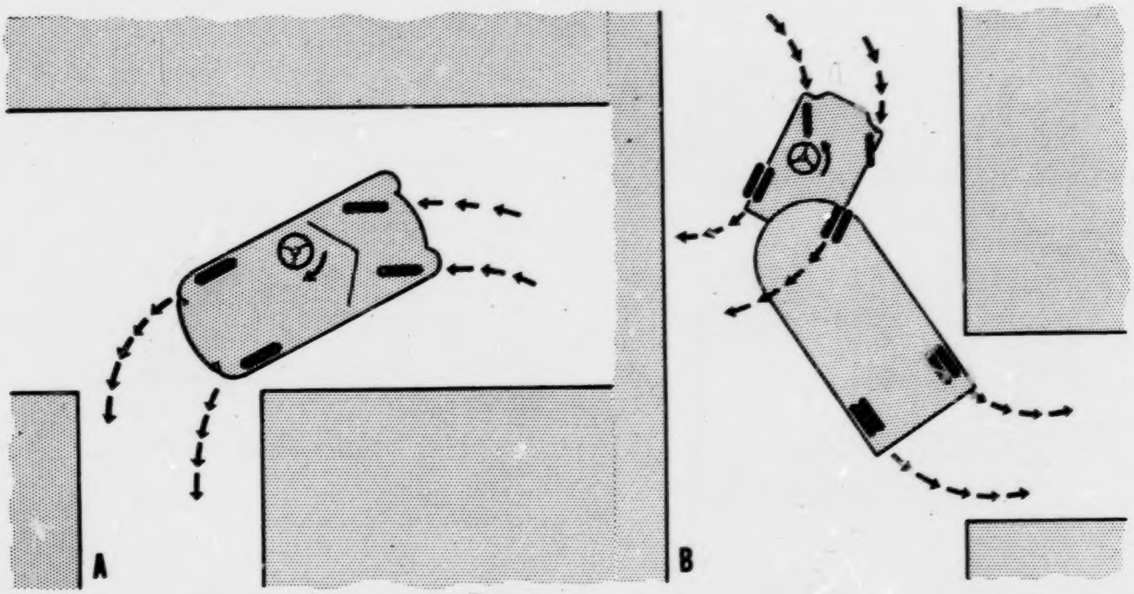
Figure 5-15.—Trailer wheels cut inside.

As the unit gets into line, straighten the front wheels and back down the alley, watching at all times to see that the semitrailer does not veer to either side. If the semitrailer angles to the left wall, adjust it to the right by turning your steering wheel to the left. If the semitrailer veers to the right, adjust it to the left by turning your steering wheel to the right.

A left-hand back is easier, because you can see the trailer from the driver's side of the cab. Of course, the direction you turn the steering wheel is just the opposite to a right-hand back.

Remember that to back the semitrailer to the right you turn the steering wheel to the left, and to back the semitrailer to the left, you turn the steering wheel to the right. (See fig. 5-18.)

A skidding tractor-trailer unit is handled in a slightly different manner than a conventional vehicle. Turn your wheels immediately in the direction of the skid, accelerate slightly and (ONLY if the tractor is equipped with independent controlled brakes) apply the trailer brakes off and on gently so that the wheels will



115.48

Figure 5-16.—A. Steering wheel right for car. B. Steering wheel left with trailer.

not lock. The trailer will then act as a drag and tend to pull both units back in line.

If the trailer starts to skid, handle it like a conventional vehicle, that is, do not apply brakes and turn in direction of skid.

BUSES

You must be at least 21 years old to operate a military bus.

When operating buses to transport personnel, you will have responsibilities in addition to those concerning the operation of trucks and trailers.

Whether you operate a small shuttle bus on the base or a large passenger bus through a community from installation to installation, you are expected to observe a schedule of arrivals and departures, and to account for your runs on the Vehicle and Equipment Request and Record, NAVFAC 9/11240/1.

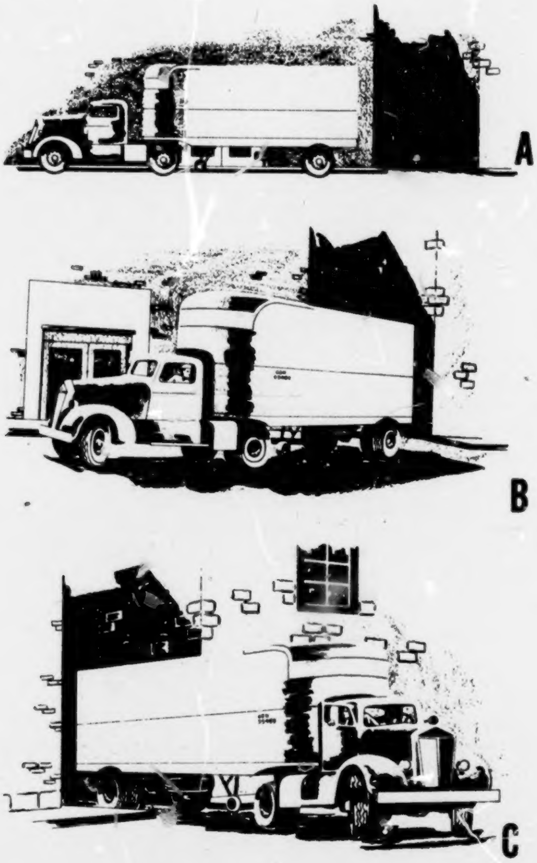
Operation

The following rules for the operation of buses are supplementary to those applying to all motor vehicles:

1. Only operators with satisfactory records of safe driving will be assigned to drive buses.
2. Operators must be trained to stop, start, and operate buses smoothly and without jerks or sudden changes in acceleration.
3. Operators must not put vehicle in motion with the doors open.
4. Operators must not close the doors of a bus until passengers are completely clear of the bus when discharging, or fully inside and off the steps when entering the bus.
5. When making a turn or upon approaching a sharp curve, operators must reduce speed and use care to avoid injuring passengers.
6. The bus operator must give his attention to the road when driving and will not carry on unnecessary conversation with the passengers while the vehicle is in motion.
7. Operators of fare-charging buses will not make change while the bus is in motion.

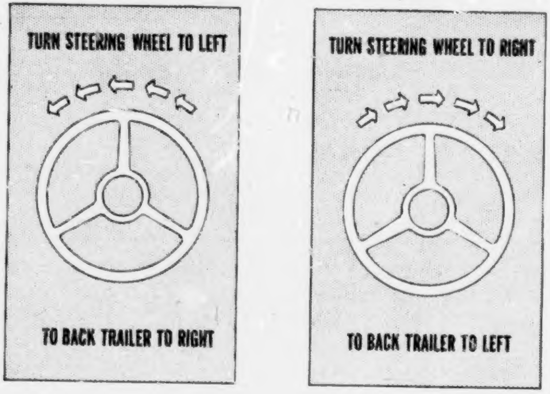
Regulations

The driver of a school bus is required to exercise all precautions listed above in addition to the following special precautions:



A. Pull past alley.
B. Turn steering wheel left.
C. Turn steering wheel right.

115.49
Figure 5-17.—Making a blind back into alley.



115.50
Figure 5-18.—Position of steering wheel in backing.

1. Speed. No shcool bus will be driven at a speed greater than that authorized by the laws of the state in which the vehicle is being operated. When children are on the bus the speed must be not more than 45 miles per hour.

2. Orderly Conduct. Passengers will be under the authority of and directly responsible to the operator of the bus, and the operator will be held responsible for the orderly conduct of the passengers.

3. Regular Stops. Pick up or discharge of any passenger except at regular stops designated by commanding officers or their representatives is prohibited.

4. Railroad Crossings. Before crossing any railroad track or tracks, you must stop the bus within 50 feet but not less than 15 feet from the nearest rail of such railroad; while stopped, listen and look in both directions along the track for any approaching train; do not proceed until such precautions have been taken and until you have ascertained that the course is clear.

5. Crossing Street. Whenever a school bus stops to discharge passengers who must cross the street or highway in order to reach their destination, such passengers must cross in front of the bus, except when laws regulating local traffic prohibit this. In case of separated lanes with a median strip, the rule applies to both roadways. The bus must not be started until passengers desiring to cross have done so.

6. Escorting Children. The operator of a school bus must not permit pupils to cross a street or highway until they can do so safely, and he will, if necessary, secure the bus, dismount, and act as their escort.

The following precautions apply to operation of semitrailer buses.

1. Passengers

a. Standing in moving vehicles is prohibited except where handholds or straps are provided for each standee.

b. No passenger will be permitted to ride on running boards or with arms or legs extended outside the vehicle, or seated on fenders, top of cab, cab shields, or in door wells.

c. No passenger will be permitted to get on or off while the vehicle is in motion.

2. Exit-Entrance

a. Exit-entrance on semitrailer buses without doors should be equipped with a heavy gage safety chain across the opening 36 inches above floor level. Chains should be attached by a secure latching arrangement which will permit easy latching and unlatching.

b. The following signs must be posted at or near the inside of the exit and entrance of semitrailer buses not equipped with doors:

"SITTING OR STANDING ON STEPS
OR IN DOOR WELLS IS PROHIBITED"

"SAFETY CHAIN MUST BE LATCHED
WHILE BUS IS IN MOTION"

• DUMP TRUCK OPERATION

During dumping operations, the truck should be on level ground or inclined uphill with front of truck facing downward. When the truck is in position, release the lower latches of the tailgate with the hand lever at the front left corner of the body. Now engage the power control with the dump body control lever, located in the cab (fig. 5-19). With the control lever at the farthest forward position (D), accelerate the engine moderately; do not race it. Hydraulic pressure will begin to hoist the dump body.

As the body rises, the load will slide backward under the open tailgate (fig. 5-20A). If the load piles up and blocks the tailgate (fig. 5-20B), place the truck in low gear and move it forward until there is more space to dump the remainder of the load. Do not change the position of the body control lever. If the load does not slide out easily, have someone dislodge it with a long hand shovel (taking care not to stand in the immediate dumping area.) When dumping a load containing rocks or other large solids, the tailgate should be latched at the bottom, but unfastened at the top so that the tailgate can drop

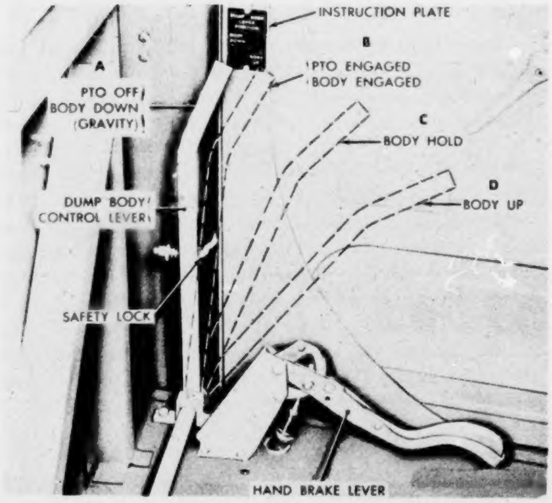


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Figure 5-19.—Dump body control lever.

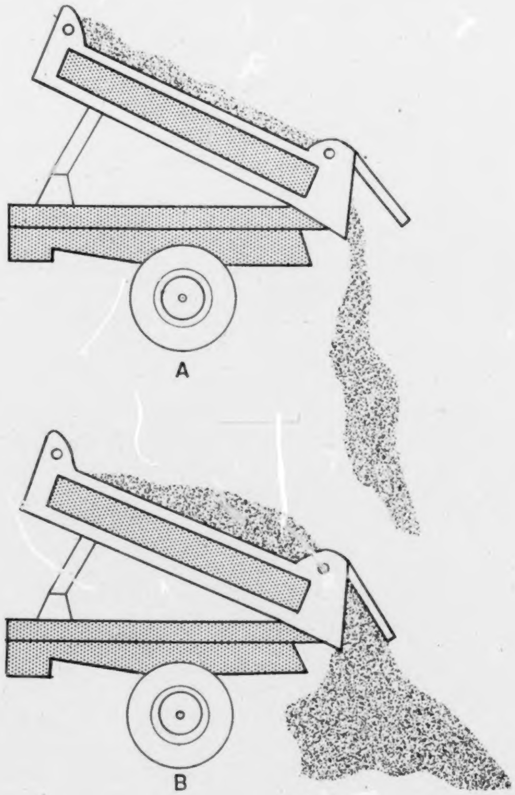

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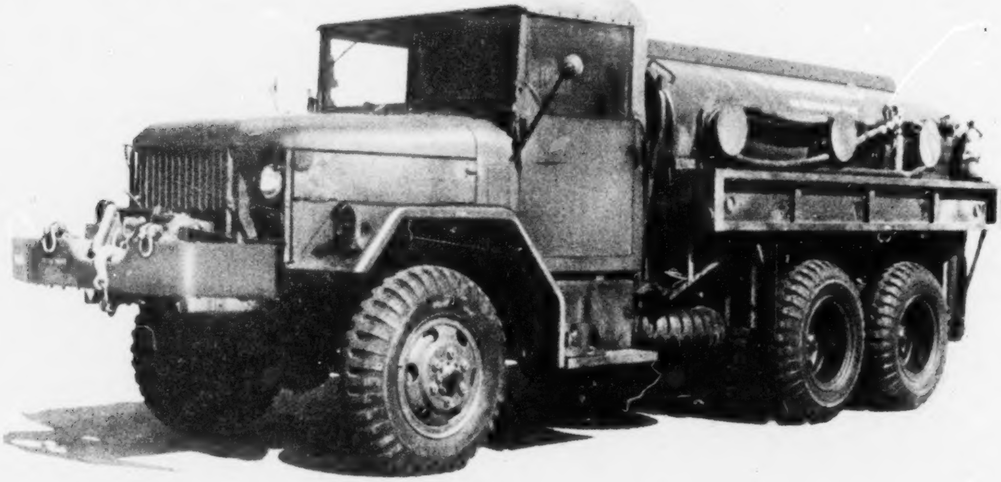
Figure 5-20.—Dumping the load.



115.431

Figure 5-21.—Fuel tank truck.

down and the load can drop. To spread a load over a large area, shift the truck into low gear and drive it slowly forward while dumping.

You can hold the body in any position by returning the control lever to position C. (See fig. 5-19.) When dumping is completed, lower the body by returning the control lever to position A. Then close the tailgate latches.

TANK TRUCK OPERATION

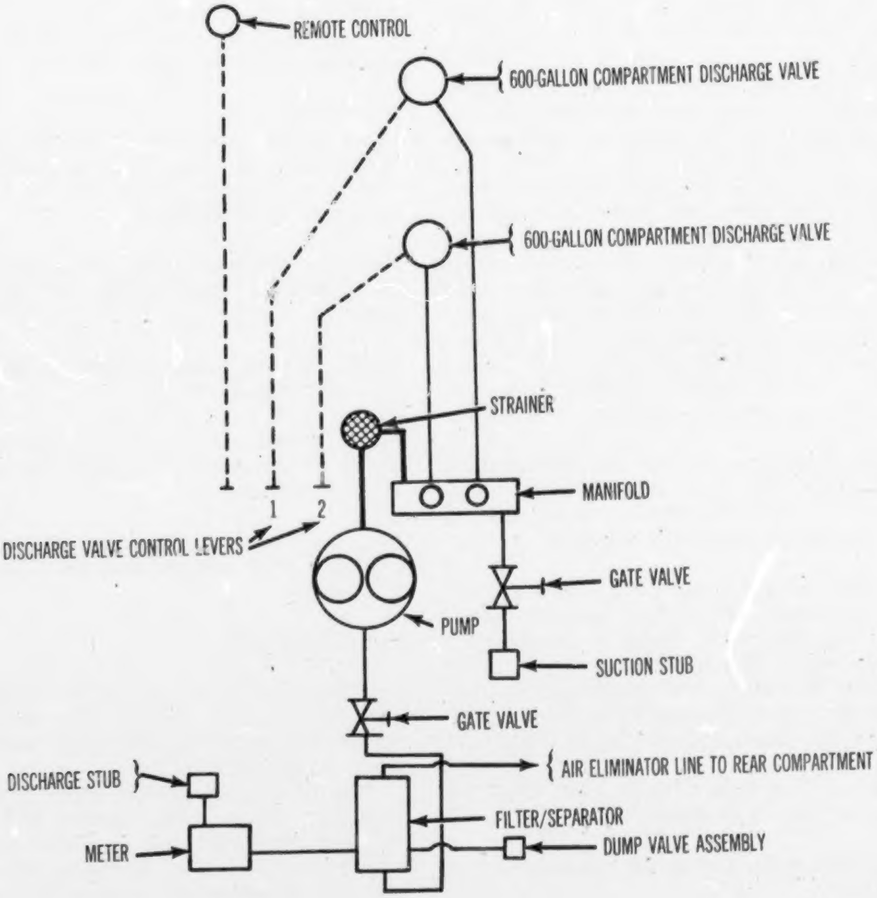
Tank trucks (fig. 5-21) are used to haul and dispense fuels or other types of liquids. The tank truck shown is equipped with a stainless steel, 1,200-gallon tank body, which is divided into two 600-gallon compartments (fig. 5-22). The fuel delivery system is equipped with an upright filter/separator and meter. Since there are only two tank compartments, the discharge valve control has two operating levers (see fig. 5-6). There is a speed control linkage assembly which controls speed of the engine, power takeoff, and delivery pump.

The filter/separator (see fig. 5-6) is equipped with three filter elements, three go-no-go fuses, a pressure gage, and an automatic dump (drain) valve. The primary function of the filter element is to collect solid contaminants and separate water from the fuel.

The go-no-go fuses shut off the fuel flow if water or solid contaminants exceed a safe level; the shutoff of flow indicates that the filters are not operating properly. The malfunction must be located and corrected, and the fuses must be replaced before operation is continued.

The pressure gage (fig. 5-6) reflects the condition of each of the filter elements and go-no-go fuses. When the pressure differential between the inlet pressure and the outlet pressure (gage handle in position 1) exceeds 20 psi, or when pressure differential between the inlet pressure and the internal pressure (gage handle in position 2) exceeds 15 psi, filter elements must be replaced. When pressure differential between outlet pressure and internal pressure (gage handle in position 3) exceeds 15 psi, replace the go-no-go fuses.

The automatic dump (drain) valve (see fig. 5-6) is float-operated. The float sinks in fuel but rises in water. When water is present in the valve housing, the float rises, the valve opens, and the water drains away through the valve drain tube. Open the automatic dump (drain) valve during fueling operations. Check pressure differential every day that equipment is in use; check it while the pump is operating, and record the readings.


REMOTE CONTROL
600-GALLON COMPARTMENT DISCHARGE VALVE
600-GALLON COMPARTMENT DISCHARGE VALVE
STRAINER
MANIFOLD
1
2
DISCHARGE VALVE CONTROL LEVERS
GATE VALVE
PUMP
SUCTION STUB
GATE VALVE
AIR ELIMINATOR LINE TO REAR COMPARTMENT
DISCHARGE STUB
FILTER/SEPARATOR
METER
DUMP VALVE ASSEMBLY

115.432

Figure 5-22.—Fuel servicing tank line diagram.

When operating the fuel tank truck for discharging of fuels, follow instructions prescribed in the manufacturer's operating manual or the directions on the inside of the equipment compartment door. The general instructions which follow are typical of the type fuel tank truck used by the Navy.

Close the meter drain valve, delivery pump drain cock, and filter/separator drain valve. Open the automatic dump (drain) valve. Enter the driver's compartment and start the engine; depress the clutch, and put the transfer shift lever in NEUTRAL; place the transfer power takeoff shift lever in the ENGAGED position; then place the transmission gearshift lever in fourth gear position, and release the clutch.

CAUTION: Allowing the engine to run with transmission engaged and the transfer shift lever in NEUTRAL without the transfer power takeoff in the ENGAGED position will cause bearing failure in the transfer case. Be sure to shift the transmission gearshift lever to NEUTRAL when not operating the power takeoff.

After the vehicle has been made ready, return to the fuel handling control compartment and set the remote hand throttle to allow the engine to operate at 700 rpm when the fuel dispensing pump is engaged. Move the discharge valve control operating lever of the tank compartment to be discharged to the open position; and be sure, before pumping operations begin, to attach the grounding wire to the vehicle being serviced. Open the pump delivery line hose and squeeze the nozzle operating lever and discharge the fuel. After discharging the fuel, close the pump delivery line gate valve, and move the discharge valve control operating lever to the closed position. Close the automatic dump valve drain tube valve and turn the hand throttle to the closed position. Return to the driver's compartment; depress the clutch and place the transmission gearshift lever in NEUTRAL; then place the transfer power takeoff shifting lever to DISENGAGED, and stop the engine.

When changing from one type of fuel to another, drain and flush the fuel compartment, pump filter/separator, service lines, manifold, meter, gage, and dispensing hoses and nozzles.

Remember, all pumping mechanisms are not controlled and operated in the same manner. You will find that each make or model will operate differently. If you are in doubt as to the proper pump operation and maintenance procedures, study the caution and instruction plates located near the pump and control mechanisms.

Drivers of fuel tank trucks must observe safe driving practices as listed below.

Drive defensively, and make allowances for other drivers.

Make turns only from proper lanes, and signal intent to other drivers. Never leave the proper lane except when necessary and then only when safe to do so.

Avoid excessive speeds at all times and especially on rough terrain, in gravel, and on curves. Be alert for passing or approaching traffic.

Drive downgrade in the same gear that would be used to drive upgrade.

Move completely off the road, if possible, when necessary to park. Set brakes, and chock wheels if stopping on a grade. Set flags during day and set flares or reflectors at night.

Stop at all railroad crossings, and be especially watchful in the case of multiple tracks.

Keep vehicle moving to prevent accumulations of vapor if a small leak develops in route. Arrange to discharge load at nearest point.

Ask for assistance if a large amount of fuel is escaping, such as might be the case if the vehicle is damaged. Immediately secure the engine, cordon the area, and obtain firefighting and security support.

Reduce refueling stops to a minimum under load. Stop the engine while refueling the prime mover.

Avoid driving past a fire or near the route until it is safe to do so.

Never smoke on or about tank vehicles used for hauling flammable liquids. Carry no matches on such vehicles.

Examine tires occasionally on long hauls for tire pressure and for damage that could cause an accident.

HAND SIGNALS

When you plan to turn, slow down or stop, you must let the drivers approaching you and the drivers following you know well in advance what you intend to do.

The hand signals for these maneuvers are shown in figure 5-23. Instead of hand signals, mechanical directional signals may be used if your vehicle is so equipped. When operating vehicles in congested areas such as construction

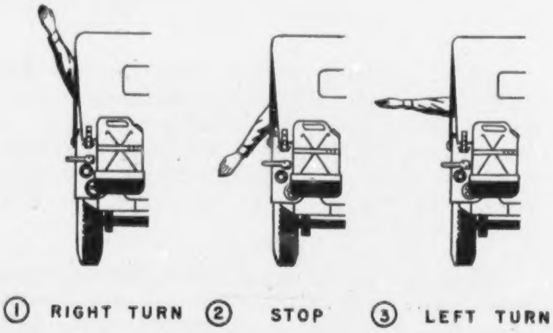


Figure 5-23. — Proper hand signals.

sites, docking areas, and pick-up and delivery areas, the hand signals depicted in Appendix I should be used. Recognize and use these Naval Construction Force hand signals during vehicle operations.

HAZARDOUS CONDITIONS

Speed should always be reduced for nighttime driving. Too many drivers try to drive just as fast at night as they do in the daytime.

Night driving is two to three times more dangerous than day driving. Fatigue and sharply reduced vision are the primary causes for increased danger. The steady hum of the motor and the darkness on the road ahead tend to lull us to sleep at the wheel. Wide-awake driving is necessary at all times and especially at night, since we can see objects only a limited distance ahead. After-dark driving requires different skills and extra care for safe driving.

Listed below are requirements and practices applicable to night driving which should be carefully observed:

1. When you meet a vehicle at night, you must lower your headlight beams when within 500 feet of the approaching vehicle.
2. Lower your headlight beams when following another vehicle within 200 feet.
3. Lower your headlight beams when you are driving on well-lighted streets.
4. Use your lower headlight beams when driving in a fog, and reduce your speed. Driving with your high beams in a fog is like shining your lights on a mirror — light is reflected back into your eyes and blinds you.
5. Avoid looking directly into the lights of vehicles that you are meeting. Instead, watch the right-hand edge of the road.
6. Keep your headlights properly adjusted so that the lower beams are not aimed upward into the approaching driver's eyes.
7. Keep your windshield clean.
8. Slow down when facing the glare from approaching headlights.
9. Be sure you can stop whenever necessary within the vision distance of your vehicle's headlights, and watch continually and carefully for pedestrians along the roadside.
10. Use you headlights during the period from one-half hour after sunset to one-half hour before sunrise, and whenever visibility is reduced.

When overtaking and passing other vehicles on the road, observe the common rules of passing. Use extreme caution whenever passing a vehicle as the view immediately beyond the other vehicle is blocked on that side. The greater the speed of the vehicle ahead, the more road space and time will be required to overtake and pass the vehicle.

Listed below are restrictions for overtaking and passing:

1. Do not pass to the right of another vehicle, except on multiple-lane divided highways (more than two lanes of traffic moving in one direction) and only then if such passing is permitted; use extreme caution in such instances.
2. Do not pass at an intersection or railroad crossing.
3. Do not pass on a hill or curve, except on multiple-lane, divided highways.
4. Do not pass a vehicle that is signaling to turn or to move into your lane of traffic, or one that has started to overtake and pass another vehicle.
5. Do not pass when the centerline of the road is solid on your side.
6. Do not pass where the highway is divided by two solid lines.
7. Do not pass when the single centerline is solid.

Rain, snow, ice, or fog affect visibility, stopping distance, maneuverability, and vehicle-control. Follow these suggestions for driving under such conditions:

1. Adjust the speed of the vehicle to existing conditions.
2. For normal conditions, allow at least one car length between vehicles for every 10 mph that you are traveling. Increase the normal safe distance between vehicles to allow for wet conditions.
3. Use tire chains or snow tires on ice or snow; however, they are only an aid to increase traction and will not eliminate the necessity for added caution.
4. Slow down when approaching bridges, overpasses and shady areas in the road; surfaces in such areas often freeze before regular roadway surfaces and remain frozen longer.
5. Keep the outside of the windshield and windows clear of snow, ice, and frost at all

times, and use the vehicle defroster to improve visibility; use extreme caution when driving in fog.

6. Apply brakes with a light pumping action to prevent skidding and use engine compression to help control the vehicle.

7. Signal well in advance to warn others of an intended stop or turn.

Superhighways, designed for high speed driving, require drivers to be more skillful and alert to avoid accidents. When entering expressways, yield to all traffic. While traveling, allow necessary distance between vehicles for safe stopping; avoid highway hypnosis by making rest stops and opening vents or windows; and never exceed the posted speed. During emergencies, get the vehicle off the roadway; use flasher lights or flares behind the vehicle to warn other motorists; and look behind for on-coming or passing traffic before opening vehicle doors. When leaving expressways, get in the proper lane well before the turn-off, and use turn signals to warn other drivers.

When driving through water, reduce speed to prevent brake drums, engine and ignition from getting wet. Test the brakes for effectiveness immediately after leaving the water. If water has entered the brake drums and wet the linings, drive at a very slow speed while gently applying sufficient pressure on the brake pedal to cause a slight drag, thereby squeezing the brake linings against the drums and forcing the water out of the linings.

Snow and Ice

Snow and ice severely limit the traction of any vehicle. To increase traction, put chains on all driving wheels. When moving over fresh snow, maintain a slow, steady speed. Rapid acceleration is likely to cause skidding, or cause the wheels to dig in. If your vehicle becomes stuck in a hole in the snow, rocking it back and forth by shifting from forward to reverse may enable you to start again. Brakes, when used, should be applied lightly and released quickly if skidding begins. If you are driving hauling equipment that includes a trailer, apply only the trailer brakes, or at least apply them first.

Hard packed snow or ice is even more dangerous to drive on than newly fallen snow. Snow tires are not much help on ice, as they add little or no traction and give you a false feeling of security. Deflating the tires a bit will assist in preventing skidding.

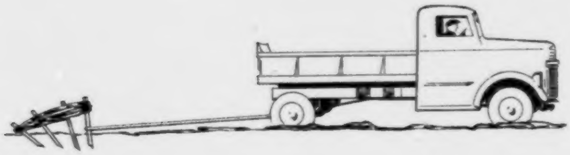
Mud, Sand, and Swamps

When approaching a stretch of sticky soil or of muddy or swampy ground, put chains on the rear wheels to save yourself a lot of distress. If chains are not available, and the going looks rough, go into the necessary low gear. Engage the front-wheel drive, if the vehicle has one. Size up the road ahead so that once you start you can keep going. As far as possible avoid ruts, holes, and edges that may cause side slips and swaying loads. Speed should be maintained, but do not spin the wheels. If the wheels start to lose traction, decrease speed but stay in the same gear. If the vehicle should become hopelessly bogged down, do not spin the wheels and burn up the tires, and do not overtax the equipment. Instead disengage the clutch at once, and get out and look the situation over. How to get out of bad situations depends on circumstances.

You may be able to back out and select a better way through. If you have wheel mats, use them. You may be able to jack up one wheel and place brush, boards, rocks, or similar material under it, enabling you to pull out. You may be able to dig your way out by digging a ditch in the direction that the wheels are expected to move. When the wheels are in deep ruts, ditches dug at an angle to the ruts may be necessary to assist the wheels back to a straddle position over the rut.

Of course, if a suitable tow truck is available, use it to get out of trouble. If your piece of equipment is equipped with a winch, use it to pull yourself out.

If the truck has dual wheels, use two tow ropes and six strong stakes. Drive two stakes into the ground the same distance apart as the wheels. Drive these stakes in front of the truck, if the best route out is forward, and behind if the best route is backward. Use the other four stakes as anchors. (See fig. 5-24.) The loop ends of the tow ropes are secured to the wheels by passing them between the duals, out through the spokes, and over the hub. The ropes are then attached to the anchor stakes. When this is done, the vehicle can move out on its own power by allowing the tow ropes to wind up between the dual wheels.



115.43
Figure 5-24.—Stake method of getting unstuck.

If stuck in sand, chicken wire on heavy burlap or canvas tarpaulins staked to the surface will aid greatly in supporting the load of the truck—and usually will get you out. In some cases, sand is somewhat encrusted below the surface and the vehicle will continue to creep forward even though the wheels spin. As long as the vehicle continues to move, the wheels may be kept spinning slowly, allowing your vehicle to dig its way out. Do not allow the vehicle to develop a differential jump; should this occur STOP VEHICLE and try another solution. You may have to let some of the air out of your tires to pull through a stretch of sand but, as a general rule, it is bad practice to run on underinflated tires. In going through sand, as in going through other tough spots, it is essential to maintain momentum and keep going. Changing of gears must be avoided by selecting the proper gear before entering the sand.

Fording

You have probably seen pictures of SEABEES driving their equipment ashore through several feet of water after unloading it from an LST. You may never drive ashore from an LST, but there may be times when you will have to drive through water.

Before you start through water, whether fording or crossing a stretch of flooded highway, be sure that the water is not so deep that it will drown out your motor. Also make sure that the surface under the water will support your vehicle. As a rule, nothing is gained by attempting to use momentum in crossing streams or other water. Cross slowly in a low gear. If there is any danger of water surging or splashing into the fan, disconnect it before crossing. After crossing the stream, apply the brakes intermittently until dry enough to hold. At the first opportunity, wheels, crankcase, universal joint, differential, transmission, and other parts submerged should be checked to determine that no water has entered.

SECURING

When returning to the equipment pool area at the end of the day's run, top off fuel tanks, check oil and coolant levels, and position vehicle in a safe manner. Let engine idle, check instrument readings, secure footbrake or handbrake, place transmission in neutral, secure engine by turning off ignition switch, complete daily trip ticket, roll up windows, secure doors, block vehicle if required, drain air tanks (if so equipped), and turn in required reports to the dispatcher.

OPERATOR'S MAINTENANCE

Every Equipment Operator is required to perform certain daily maintenance services on his vehicle as a matter of routine. The faithful performance of these services does much to prolong the life of the vehicle, to avoid major repairs and overhaul, and to assure the Equipment Operator that his vehicle will perform consistently and dependably. OPERATOR'S MAINTENANCE is the term that describes the required inspection, service, lubrication, and adjustments performed by an operator to keep power tools and equipment in a safe operable condition, in order to prevent personnel injuries, mechanical malfunctions, and curtailment of production or progress.

FAN BELTS

Worn or loose fan belts are often the cause of engine overheating, especially when the engine is operating in low or second gear. Excessive looseness or tightness can be determined by applying the manufacturer's specified pressure to the belt at a point midway between the fan and the generator pulleys and determining that the deflection is within the range specified for the vehicle.

If it is necessary to adjust the fan belt, first look at the type of device used to provide the fan takeup and follow the manufacturer's adjusting procedures.

IGNITION AND ELECTRICAL SYSTEMS

Ignition troubles are often a major cause of improper engine performance. When an ignition tuneup is required, it includes checking the battery, cleaning and inspecting all wires and terminals, cleaning or replacing and adjusting spark plugs, checking ignition timing, and adjusting breaker points. These are important jobs in an ignition tuneup, but you, as an EO, are only required to check the battery and clean and inspect all wires and terminals. An experienced mechanic using proper equipment will adjust and check timing and ignition breaker points, and clean or replace and adjust spark plugs to the manufacturer's specifications.

BATTERY AND BATTERY CONNECTIONS

The storage battery supplies power for all electrical accessories. The condition of the battery is the first concern in accessory maintenance. Check the battery periodically for water, and see that the battery terminals are tight and free from corrosion. If the battery fails to supply sufficient power to turn the starter or to operate other electrical units on a vehicle, report this malfunction to the maintenance section for corrective action.

Most electrical troubles can be traced to poor ground connections, loose wire connections, and worn or frayed wires that cause short circuits, rather than to a defective battery.

Tightening a loose wire connection is a simple operation; a worn, frayed, or broken wire should be taped to make temporary repairs ONLY. THE VEHICLE SHOULD BE TAKEN TO THE SHOP WHERE A MECHANIC WILL REPLACE THE WIRE WITH A NEW ONE.

COOLING SYSTEM

You will need to drain the coolant from the cooking system occasionally to remove sediment and rust scales and for periodic radiator flushing. Be sure all the coolant is removed.
The manufacturers' maintenance manuals will show you the locations of drain cocks and plugs, which are usually found in the lowest points of the systems.
When refilling a cooling system that has been drained, allow water to pass through the engine and out the drain openings before closing them. When the water is clear and flows freely from the openings, close them securely and fill the cooling system slowly. Never add water faster than it can circulate through the various branches of the system, since water overflowing from the cap may give a false indication of a full system. Do not add water to the cooling system of an overheated engine; allow the engine to cool first. If you must add water before you are sure the engine is cool, run the engine and add water very slowly. Cold water in an overheated engine may crank a cylinder block or cause other serious damage to engine parts.

WHEELS AND TIRES

You should become familiar with the recommendations of tire manufacturers on the proper use and care of tires on vehicles. Probably one of the most common mistakes is incorrect tire pressure. To keep vehicles operating continuously and efficiently, you must follow the procedures recommended by the manufacturer for inspecting and inflating tires. To get the maximum life from a tire, you must maintain proper tire pressure to match the load the vehicle will carry at its actual operating speed. You must make periodic pressure checks on cold tires (before running equipment), and make visual inspection of tires for tread cuts, sidewall snags, and wear. Check wheel rims for splits, metal fatigue, and out-of round condition.

When tires are to be removed, take the equipment to the tire shop, where special tools and personnel are available to replace or repair the tires. You will be required to help the tire repair personnel to disassemble and repair the tire. Detailed procedures on this will be given later in the chapter.

BRAKE SYSTEMS

When inspecting hydraulic brakes, ensure that the proper level of hydraulic fluid is maintained in the master cylinder reservoir, and check the system for leaks and worn parts. Be sure to add the kind of hydraulic fluid recommended by the manufacturer, because some brake systems are made with natural rubber seals and others with synthetic seals. Unless the recommended fluid is used, the seals will deteriorate quickly and the hydraulic brakes will not operate.

Dust and dirt that accumulates around the filler plug opening can also affect brake operation. A small particle of dust or dirt that may find its way into the operating mechanism can close a vent or prevent a valve from seating properly. See that all dust and dirt are removed before you uncover the master cylinder and add fluid. Add enough fluid so that the level reaches just below the filler plug opening. After filling the reservoir, see that the vent at the top of the reservoir is open and the filler plug is tight.

Leaks and loose joints in the brake system not only allow fluid to escape but also permit air to enter. Air in the hydraulic system can be felt by the soft, springy action of the brake pedal, and must be removed by bleeding to obtain a solid pedal. When bleeding becomes necessary, take the vehicle to the maintenance shop, where special tools and personnel are available to correct the situation.

When inspecting and servicing airbrake systems, the most common problem you will find is leaking air lines. The air line hoses and couplings should be checked for leaks and wear, particularly those connecting a truck and trailer. Replace worn hoses and tighten hose connections and couplings. The cutout cocks provided at the tractor hose connections are often responsible for air loss. These tapered valves should be checked often and kept tightly closed. When no trailer is being towed, they often jar open. Be sure these valves are closed tightly, but are free to open when trailer brakes are required. A little penetrating oil will free a binding cutout cock.

The drain cock at each air reservoir should work freely. Reservoirs should be drained daily to remove water that accumulates from condensation.

BODY AND FRAME

The mobility of NMCBs results in frequent shipment of vehicles, with consequent likelihood of damage to the body and frame during shipment. Of course, accidents are another cause of body and frame damage.

During the operator's maintenance, the EO will inspect the body and frame of the vehicle. He will look for damaged portions of the body and report the damage so that repairs can be made by the body shop personnel. These body repairs include straightening body panels, replacing body parts, and repainting.

If damage to the frame is detected by your inspection, this will also be reported and the body shop personnel allowed to repair the damage, if they are equipped to do so. If they do not have the equipment, the vehicle must be sent to a larger repair facility equipped with frame straightening machines.

LUBRICATING OIL SYSTEM

Check the oil level and, if necessary, add additional oil for a FULL gage or dipstick reading. Do not overfill.

If the oil feels gritty to the fingers or has no body, it has lost its effective lubricating qualities and must be changed.

Oil changes should also be made in accordance with the manufacturers' lubrication and maintenance schedules. On most of your equipment, the grade and quantity of the oil to be used will be found on the lubricating charts.

Drain the oil only after the engine has run and is warmed up. This warmup period will thin the oil and stir up the sludge and foreign matter in the oil pan. After replacing with new oil, recheck the oil level to be certain that the oil column reaches the FULL mark on the dipstick. Then run the engine for a few minutes to ensure no leaks exist, particularly around the oil filter and the oil drain plug. Get into the habit of looking at the ground or pavement over which the vehicle has been parked, for any oil spots that may indicate leakage.

Changing oil filter elements periodically will be part of your job. Usually the filter elements are changed at the same time the oil is changed in the crankcase. On new engines it may be changed (1) after the first 500 miles; (2) according to the manufacturer's instructions; or (3) according to shop policy. The filter element should be replaced with the type recommended by the manufacturer. Be sure to remove the old gasket and see that the new gasket under the cover or in the crankcase is properly fitted, and that there are no oil leaks. Always check these points immediately after starting the engine.

FUEL SYSTEM

The fuel system consists of the fuel tank, fuel pump, carburetor, intake manifold and fuel lines or tubes connecting the tank, pump, and carburetor.

Fuel tanks give little or no trouble, and as a rule require no servicing other than an occasional draining and cleaning. If, during inspection, you should find the fuel tank either punctured or leaking, report the trouble, leaving the repairs or replacement to the repair shop where there are proper servicing facilities. All fuel leaks will be considered cause for immediate shutdown.

If the presence of gasoline in the crankcase is observed, it is a good indication of a diaphragm leaking within the fuel pump. Usually, the mechanics will replace the pump or repair it using a repair kit for this purpose.

Inspect the fuel lines and connections, observing that the lines are placed away from the exhaust pipes, mufflers, and manifolds so that excessive heat will not cause vaporlock. Make sure fuel lines are attached to the frame, engine, and other units so that the effects of the vibration will be minimized. Fuel lines should be free of contact with sharp edges which might cause wear. In places of excessive movement, as between the vehicle frame and rubber-mounted engine, short lengths of gasoline-resistant flexible tubing are used. Occasionally, road vibration may loosen and break lines, and they can become pinched or flattened by flying rocks. Such damage could interfere with the flow of fuel.

A certain amount of scale forms within the fuel lines and sometimes causes a stoppage.

When, in the course of your daily maintenance services of the fuel system, you observe operational troubles with the carburetor; report the troubles, leaving the adjustments, repairs, or replacement of the carburetor with the maintenance personnel equipped to handle these troubles.

LUBRICATION

As you may recall from Chapter 3, lubricants act as cooling agents, sealing agents, cleaning agents, and reduce friction and wear. This section discusses the procedures of lubrication.

Periodic lubrication prolongs the usefulness of a vehicle. Proper lubrication is more than merely placing a grease gun on a fitting and pulling the trigger. It means selecting the correct lubricants and applying them in a sufficient amount and in the proper places. The experienced equipment operator uses neither too much nor too little lubricant.

Lubrication, then, is a thorough job of oiling and greasing. The lube rack will likely carry several Navy-approved standard lubricants. (Refer to Chapter 3 to learn their specifications and names.) This standardization of lubricants eliminates the variation and confusion in manufacturer's brand names and quality designations, and makes readily available a few standard lubricants.

Familiarize yourself with the lubrication chart of the vehicle with which you are working. The manufacturer of each vehicle has prepared a lubrication chart similar to the one shown in figure 5-25. These charts show what to lubricate, and where.

Of course, you must learn to use grease guns properly, as well as other dispensers of oils and grease.

Remember that grease on the outside of a fitting does not lubricate, and oil or grease in puddles or gobs around the grease rack can cause serious injury. So look for and remove spilled oil or grease that drops from chassis parts. Better yet, while lubricating a piece of equipment, remove all excessive grease from the fittings and wipe up lubricants that fall to the floor.

DISPENSING LUBRICANTS

Grease guns and dispensers operate either by hand or are air operated. You have probably used the hand-operated, MUZZLE-LOADER type of grease gun. This grease gun can be taken apart to load it with grease. It is generally used in places hard to reach with a pressure gun, or in lubricating water pumps and other accessories requiring a special lubricant. Lubricants used for most chassis parts, however, are forced through the fittings by guns operated by air pressure.

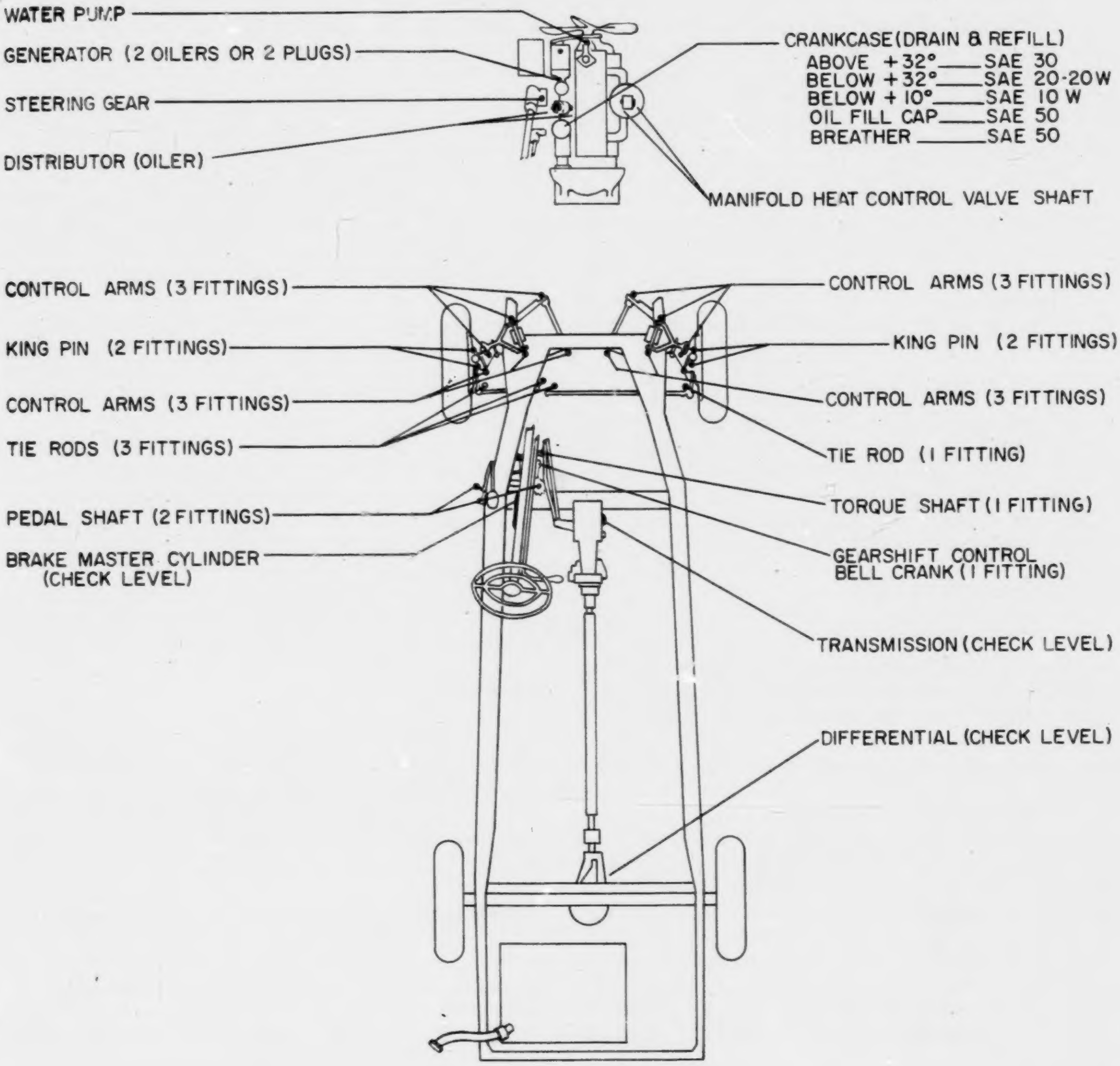

WATER PUMP
GENERATOR (2 OILERS OR 2 PLUGS)
STEERING GEAR
DISTRIBUTOR (OILER)
CRANKCASE (DRAIN & REFILL)
ABOVE +32° SAE 30
BELOW +32° SAE 20-20W
BELOW +10° SAE 10 W
OIL FILL CAP SAE 50
BREATHER SAE 50
MANIFOLD HEAT CONTROL VALVE SHAFT
CONTROL ARMS (3 FITTINGS)
KING PIN (2 FITTINGS)
CONTROL ARMS (3 FITTINGS)
TIE RODS (3 FITTINGS)
PEDAL SHAFT (2 FITTINGS)
BRAKE MASTER CYLINDER (CHECK LEVEL)
CONTROL ARMS (3 FITTINGS)
KING PIN (2 FITTINGS)
CONTROL ARMS (3 FITTINGS)
TIE ROD (1 FITTING)
TORQUE SHAFT (1 FITTING)
GEARSHIFT CONTROL BELL CRANK (1 FITTING)
TRANSMISSION (CHECK LEVEL)
DIFFERENTIAL (CHECK LEVEL)

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Figure 5-25.—A typical chassis lubrication chart.

Crankcase oil is generally dispensed with measured containers or with a hand- or air-operated pumping system. Hand- or air-operated systems normally have meters that register the amount of oil dispensed. Gear box lubricants are generally dispensed by some type of hand- or air-operated pumping system. Be sure you use the right lubricant dispensers. To prevent mistakes, each dispenser is marked to show the grade and type of lubricant it contains.

Before using the lubrication gun, all fittings which are to be lubricated MUST be properly cleaned to avoid forcing dirt into the bearing.

The proper technique for using the lubrication gun is essential. Improper use of the gun can damage the hydraulic coupler jaws and can also damage the fitting. Damaged coupler jaws will prevent proper sealing with fittings. To prevent damage, press the coupler straight onto the CLEAN fitting.

CAUTION: Care must be exercised when using a high pressure lube gun on certain lube points. Excessive pressure can damage or "blow off" the grease seals and/or dust caps. To prevent this damage, apply grease by one or two quick pulls on the trigger; this prevents excess pressure building up in the seals.

After a vehicle is lubricated, clean and fill the grease guns. Then check them to see if they are working properly. Next see that they and other lubricating equipment are stowed in their proper places. Take an inventory of your tools to be sure they are not carried away on the vehicle frame or running board.

CHASSIS LUBRICATION

Most chassis lubrication fittings are located on the front suspension and steering mechanisms. The importance of proper chassis lubrication cannot be overstressed. This lubrication should always be performed in accordance with the manufacturer's lubrication charts.

Frozen fittings, will not readily accept lubricants because the friction surface containing the fitting has dry and dirty working surfaces. Some relative motion in the connection is needed to permit the lubricant to enter the frozen fitting. Vertical rocking of the vehicle is the usual method of providing this relative motion in the coupling. In some extreme cases it may be necessary to disassemble the unit being greased in order to properly lubricate it. NEVER pass up a frozen fitting.

BODY LUBRICATION

To lubricate the hood, apply a few drops of oil on the fastener-and-release mechanism, coat the fastener pins and hooks with a light application of dry stick lubricant, and close the hood.

Car doors and trunk lids are lubricated by applying a drop or two of oil to the door latch and trunk lid mechanisms. Also apply a few drops of oil to the hinges and swing the door back and forth or raise and lower the lid to spread the lubricant over the contacting surfaces; wipe off any excess lubricant.

The door striker assembly is lubricated by applying a light coating of dry stick lubricant to all sliding surfaces and a few drops of oil to all bearing surfaces. Apply a drop or two of oil around the edge of the cylinder face and to the outer surface of push-button latches and press the push-buttons several times to distribute the lubricant. Wipe off any excess oil and lubricants.

Never use oil to lubricate locks since it collects dust and lint. Inject graphite directly into the keyhole and work the lock several times to distribute the graphite in the tumbler mechanism.

A dry stick lubricant is best used for sliding weather-stripping surfaces of ashtrays, hinged visors, glove compartments, and other hinged units within the vehicle. Hinged surfaces outside of the vehicle may be lubricated lightly with oil. Always remember that the few minutes it requires to oil these various items will, in most cases, eliminate their failure.

Generator Service

Periodic lubrication service is required by most generators. A few generators have sealed bearings which require no lubrication. The generator should be lubricated only at those intervals specified by the manufacturer's lubrication chart.

Distributor Service

The distributor requires service lubrication at three points — the shaft bearing, the centrifugal spark advance mechanism, and the cam. The shaft bearing is lubricated through either an oil cup, grease fitting, or grease cup. Some distributors are equipped with a removable access plug to the shaft bearing reservoir.

The automatic spark centrifugal advance mechanism may be lubricated through a small, round felt wick located at the top of the distributor shaft. Apply two or three drops of motor oil to the felt wick. With your finger-tip, apply a light film of high temperature type grease to the cam. CAUTION: Excess lubricant on the cam may be thrown over to the points and cause ignition failure.

Steering Gear Service

The fluid level in the gear housing should be checked at every chassis lubrication. You should clean around the fill plug on top of the steering gear housing before removing the fill plug. Do not disturb the adjusting screw locknut adjacent to the fill plug. Check the lubricant level and add lubricant, if necessary, to bring the lubricant level to the bottom of the fill plug hole. You then replace the fill plug.

Three points require lubrication in power steering systems. The gear housing is serviced as above on the linkage type of power steering. As you may recall, the linkage type of power steering system has the power cylinder and control valve connected to the steering linkage and a steering gear of conventional design. Additional lubrication fittings under the car may be found on the power cylinder or the power cylinder attachment points in the linkage type. The fluid reservoir is serviced at each chassis lubrication by cleaning the area, removing the dipstick or reservoir cover, checking the oil level, and replacing the dipstick or cover after adding oil if necessary. Power systems can become inoperative due to dirt in the system, so use care to prevent dirt from entering the reservoir during service operations.

Brake Service

The fluid level in the hydraulic brake master cylinder should be checked at every chassis lubrication. The fluid level must be visually checked at the reservoir. Pumping the brake pedal does not constitute a complete check. Service the master cylinder by cleaning the area around the fill plug, removing the fill plug, checking the fluid level and refilling the master cylinder reservoir to within half an inch below the fill hole, and replacing the gasket and fill plug. Always use the hydraulic fluid recommended by the manufacturer's lubrication chart. The use of inferior brake fluid or one which contains mineral oil will result in deterioration of the rubber seal, making it necessary to completely overhaul the brake system and flush all brake lines.

FAN BELT ADJUSTMENTS

There are many types of fan belts and many procedures used for adjusting them. It is beyond the scope of this manual to present information on all types of fan belts. Therefore, the following information presented should familiarize you with fan belt adjustments in general.

Check the fan belt (sometimes called a drive belt) tension by applying the manufacturer's specified pressure to the belt at a point midway between the fan and the generator pulley. Belt deflection at this point should be as specified. If belt deflection is found to be more or less than specified, adjust tension as follows:

1. Loosen generator-to-adjusting-arm capscrew.
2. Insert end of pry bar (fig. 5-26) between crankcase and generator so that the lower end of the bar will bear against crankcase.
3. Pull upper end of pry bar away from engine with a pull of approximately 50 pounds, and keep handle in this position; then tighten the

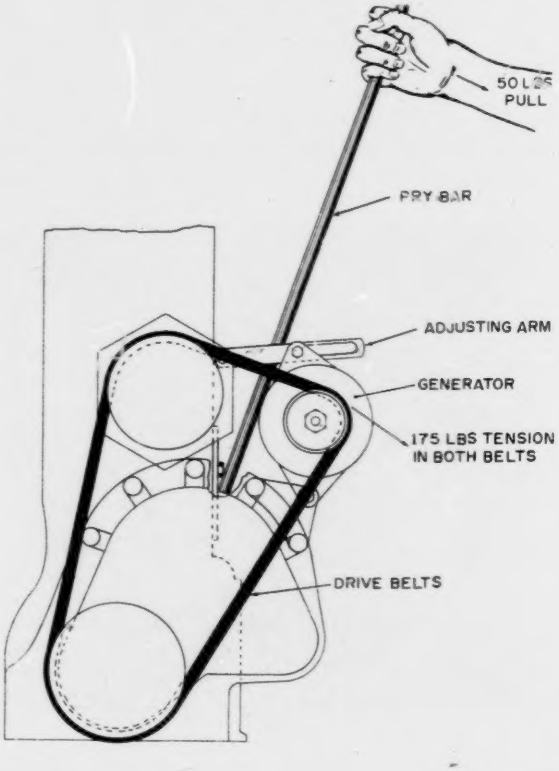

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Figure 5-26.—Adjusting drive belts.

generator-to-adjustment-arm capscrew. This procedure will place belts under proper tension and allow for specified belt deflection.

HANDBRAKE ADJUSTMENT

In most automotive vehicles, the handbrake has its own hookup. Either external-contracting brake bands are located on the drive shaft or some type of mechanical linkage operates the rear wheel brakes.

In this discussion, information on the external-contracting type brake located on the drive shaft will be given (fig. 5-27).

Handbrake controls consist of a handbrake lever connected by linkage to the brakeshoe lever at the rear of the transfer case. The handbrake is properly adjusted when it will hold the vehicle on an incline with the handbrake lever moved one-third of the way in reverse, or if application of the brake at a speed of 10 mph stops the vehicle within a reasonable distance.

To increase braking action of the handbrake turn the knurled end of the handbrake lever clockwise. To decrease braking action (to prevent dragging of the brakeshoes), turn the knurled end counterclockwise. If braking action cannot be increased sufficiently by turning the knurled end clockwise, turn the knurled end counterclockwise, adjust linkage tension at the brakeshoe lever, and then turn the knurled end clockwise until the correct brake adjustment is obtained. To adjust linkage at brakeshoe lever, hold adjusting nut on transfer end of linkage, loosen locknut, turn adjusting nut clockwise on linkage and tighten locknut.

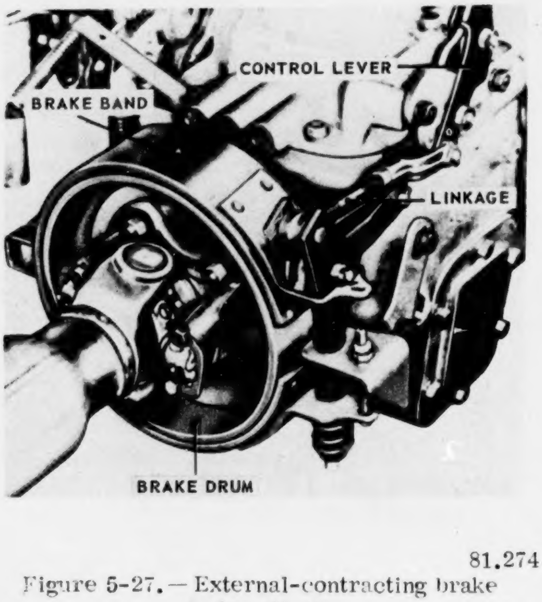

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Figure 5-27.—External-contracting brake (automotive).

TIRES

Pneumatic tires and inner tubes are designed to provide traction and cushion the shocks of the road or terrain. Traction is provided by the natural friction of the rubber upon contact with the road or terrain, aided by the tread design of the tire. Cushioning is provided largely by the air within the tube, or the tire itself if of tubeless design. Both tires and tube are flexible enough to "give" when a bump or chuck hole is struck, and they are able to resume their former shape immediately.

CHANGING A TIRE

A word of CAUTION before you lift a vehicle with a jack to change a tire: If you are to jack either of the rear wheels, place a block or stone in front of both front wheels to keep the vehicle from rolling forward and off the jack; if you jack either of the front wheels, place the block or stone behind both rear wheels.

TO REMOVE THE WHEEL, remove the hubcap, which snaps into spring clips. Then remove the five or six hub bolts or nuts that fasten the wheel to the wheel hub. Wheels on the right side are fastened with right-hand thread bolts or nuts and those on the left side with left-hand thread bolts or nuts to eliminate the tendency to loosen with wheel rotation. In raising the wheel from the ground, be careful not to push the vehicle off the jack. The spare wheel and tire should be placed on the vehicle immediately.

Removing dual disk wheels to change tires on heavy vehicles is not too difficult. Generally, both disks are fastened together by two nuts on each hub bolt—one nut for each wheel. Either single or dual wheels can be securely mounted on the same hub with this arrangement. Outer nuts must be loosened first, freeing the outer wheel disk from the hub. Loosening the outer nuts, which thread over the inner nuts, unfastens the outer wheel disk. In removing dual disk wheels you will find left-hand threads on both inner and outer nuts on the left wheels and right-hand threads on those of the right wheels. The dual wheel mounting is illustrated in fig. 5-28. Reverse the procedure to mount and tighten the wheels.

On trucks having spoke wheels, the tire and tube are removed with the rim. After removing the clamps which secure the rim on the spoke spider (fig. 5-29), the rim with the tire and tube can be lifted off. If the spoke wheel has two rims and tires, the second rim and tire can be lifted off after the spacer separating the rims is removed. In replacing the tires, the inner rim should be placed so that the valve stem can be reached easily for periodic inflation.

A tire demounter should be used to remove a tire from the rim.

In mounting a tubed tire, inflate the tube until it is almost round. Put the inside bead of the tire on the rim and insert the tube into the tire with the valve at the red (balance) mark on the tire. Guide the valve stem through the valve hole. Be sure the valve stem is pointed in the right direction if you are mounting the tire for use on dual wheels. And if it is a rubber stem, see that the stem enters the hole without bending.

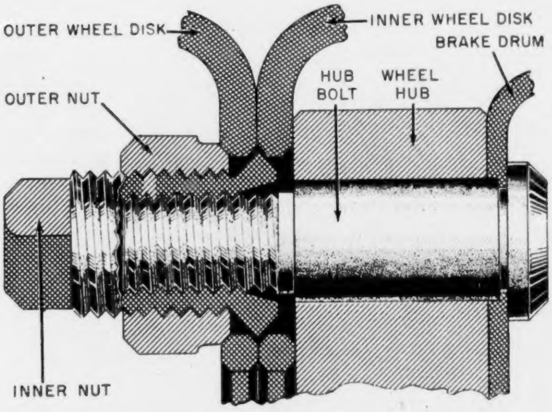

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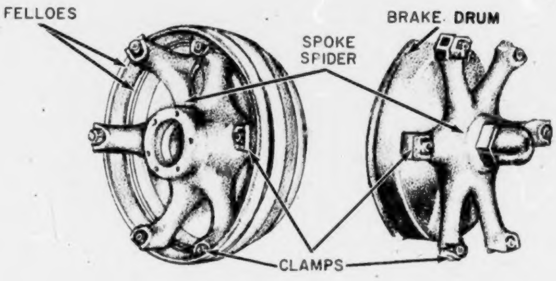
Figure 5-28.—Dual disk wheel mounting.



29.112
Figure 5-29.—Truck spoke wheels.

The first bead will slide in rather easily, but the second bead may offer a little trouble. Use the tire irons, and work both ways from the stem to slide both tire beads in the rim walls. DO NOT PINCH THE TUBE. Use a rubber mallet (NOT a hammer) to strike the center of the tread around the tire to help seat the second bead and the tube properly. On other than drop center rims, see that the lock rings are securely fastened.

Inflate the tire slowly after mounting it on the rim. See that the tire beads fit snugly against the rim flanges, and that lock rings are turned face down and remain in the locked position. Serious accidents can result from failure to observe these precautions. Too much pressure applied at once can cause a lock ring to fly off the rim or the tire itself to be blown off and seriously injure personnel. Inflate tires inside a STEEL TIRE CAGE. This will confine the tire enough to keep it from striking you in case either it or the ring bursts its fittings.

TUBELESS TIRES

Most of the lighter Navy vehicles and some of the heavier vehicles now are equipped with tubeless tires. Instead of being sealed in an inner tube, the air in these tires is sealed in a space between the outer casing and the rim. Both this space and the point of contact of the tire against the rim must be airtight. The rim, on which the valve for inflating the tire is mounted, becomes a part of the air retaining chamber. When using

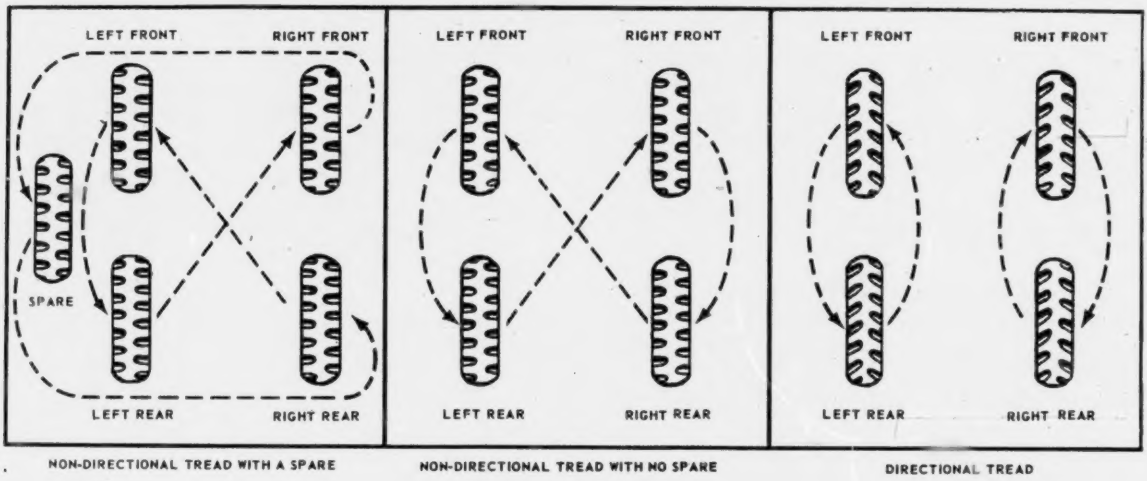


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Figure 5-30.—Recommended tire and wheel rotation.

tire irons, exercise care not to tear or otherwise injure the sealing ribs or beads on the tire being repaired.

Before replacing a tubeless tire, examine the rim carefully for dents, roughness, and rust, any of which may impair or break the air seal. Straighten out any dents with a hammer, and use steel wool to clean the bead seat area of any rust or grit. If the rim is badly bent or out of round, a new wheel should be installed on the vehicle.

Removing and remounting a tubeless tire are similar to the operations for tubed tires. If the tire seal is broken or defective, it will be necessary to use a tube inside the tire. Otherwise, the tire will lose air, and you will have to inflate it frequently. Some tubeless passenger car tires must be removed from the rear of the rim to prevent stretching the bead wires too far and causing them to break. If in doubt about any other details of changing tubeless tires, follow the tire manufacturer's instructions, or consult with your supervising petty officer.

ROTATING TIRES

Rotating tires is recommended by the manufacturer. This must be done every 5,000 miles on Navy vehicles, and entered in the Vehicle Service Jacket. If several tires show more wear than others, or if the mileage is approaching another 5,000-mile interval, you will rotate all the vehicle's tires in the following manner:

1. On automobiles having a spare tire, the left front tire should be moved to the left rear, the right front to the spare, the two rears to the opposite front wheels, and the spare to the right rear. (See fig. 5-30.)
2. On automobiles having no spare, move the front tires to the rear on the same side, and move the rear to the opposite front wheels.
3. On vehicles having six tires (dual tires on rear), new tires should normally be mounted on the front wheels for one-third of their life, then moved to the outside rear wheels for another third, and finally shifted to the rear inside wheels. A few service conditions which demand maximum traction on rear wheels may require that new tires, or tires with relatively good treads, be mounted on the rear wheels.

CAUSES OF TIRE WEAR

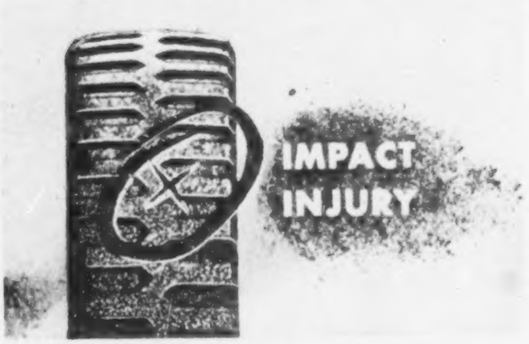
Pneumatic tires have been installed on many items of equipment to increase mobility and efficiency. However, unless tires are properly cared for, much of this efficiency and mobility is lost to the user.

Probably the greatest factor in prolonging the life of pneumatic tires is PROPER INFLATION. Correct tire pressure cannot be checked by kicking the tire. It requires the use of a pressure gage. Tire pressure checks should be made prior to the vehicle being moved. This can be accomplished during the "Before Operation Services." (Don't forget to check the spare tire.) If the pressure is neglected, the results can be costly. Tire pressure should be stenciled on the dash or fenders.

Abnormal wear from IMPROPER TIRE INFLATION can be divided into four categories. These are: overinflation, overinflation-impact injury, underinflation, and under inflation injury. Let's look at each of these indetail, and learn how to get maximum life from our tires.

OVERINFLATION stretches the tire and permits only the center section of the tread to come in contact with the road. Since the wear is concentrated on the central part of the tread, the indication of overinflation is wear in the center of the tread. (See fig. 5-31.) An overinflated tire has no give and is constantly subjected to hard jolts, causing the drive wheels to bounce and spin, literally abrashing the rubber. There is also less tire to road surface contact with an overinflated tire and this causes a safety hazard in both braking and sliding.

An overinflated tire is more susceptible to impact injury because the cords are stretched tight. In this condition, the tire will not give or flex and distribute the shock over a great area of the ply cords. Therefore, when the tire hits an obstacle the cords snap, leaving the characteristic "X" type break illustrated in figure 5-32.



81.501

Figure 5-32.—Overinflation-inpact injury.

The external indication of an underinflated tire is more wear on the edges than in the center of the tread. (See fig. 5-33.) UNDERINFLATION causes excessive movement and scuffing between the tire and the road, which in turn results in faster tread wear. There may be occasions when chains are not available and tire pressures must be lowered to get better traction in sand, ice, mud, and snow. When this occurs, prescribed pressures for these conditions should be maintained to prevent tire damage.

The inside of a tire that has been run underinflated may appear as shown in figure 5-34.

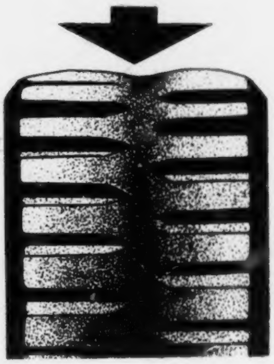


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Figure 5-31.—Overinflation.

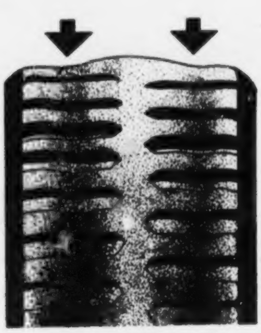

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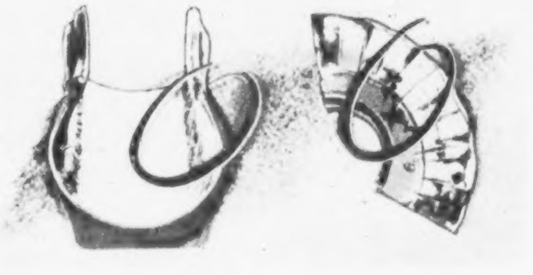
Figure 5-33.—Underinflation.



81.503
Figure 5-34. — Results of underinflation.

The excessive flexing and movement of the ply cords cause a tire to get hot resulting in separation of cords and rubber. When the cords are separated from the body as shown the tire is permanently damaged and must be replaced. This replacement is a direct result of operator neglect and not fair wear and tear. While the tire must be removed from the wheel to properly identify this condition, in many instances radial cracks will appear on the outer wall of the tire which will serve as a warning that the tire has been operated underinflated.

All uneven tire wear is not caused by improper inflation. Mechanical irregularities may cause some tires on your equipment to look like those shown in fig. 5-35. Wear of this type can be caused by wheels out of line or improperly balanced, excessive toe-in or toe-out, or improper camber. Uneven tire wear can also be caused by operating a vehicle with the front wheel drive engaged on dry hard surfaced roads. When uneven tire wear occurs, the mechanical defects must be corrected immediately and the tires rotated.

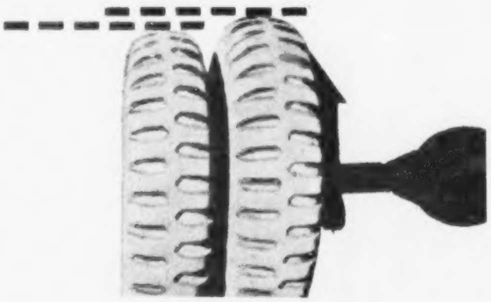


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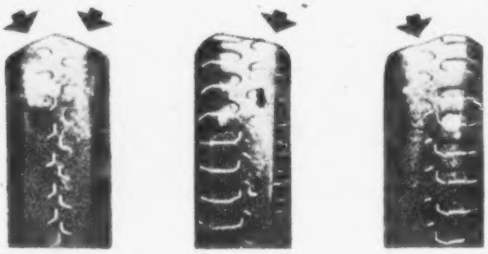
Figure 5-35. — Results of mechanical irregularities.



81.505
Figure 5-36. — Mounting of duals.

The proper selection and mounting of tires for dual assemblies is extremely important. Mismatched tires cause uneven distribution of the load which defeats the purpose of the duals. (See fig. 5-36.) In this case, the larger tire carries the greater load, subjecting it to excessive wear and early failure. Also, the smaller tire wears more rapidly than normal. It scuffs along without sufficient road traction causing excessive wear. Since you are not always able to match sizes of tires exactly, except with new tires, certain tolerances are allowed. If the tires are size 8.25 or smaller, a differential in diameter of 1/4 inch is acceptable. On larger tires, over 8.25, up to 1/2 inch is allowable. Even when the sizes of tires are within these tolerances, the larger of the two duals should always be mounted on the outside so that they will conform to the "crown" of the road and shoulder the load more evenly.

Illustrated in fig. 5-37 is the directional bar tread type tire. It is commonly used on road graders and other earthmoving equipment. The bars and open center pattern are designed to permit each bar to dig in deep, take a firm hold, and give maximum traction in soft, muddy, or slippery surfaces. Since this is a directional tread tire, it must be mounted on live axles so the point of the "V" comes in contact with the ground first. When the directional tire is mounted in this manner, it is "self-cleaning." It forces

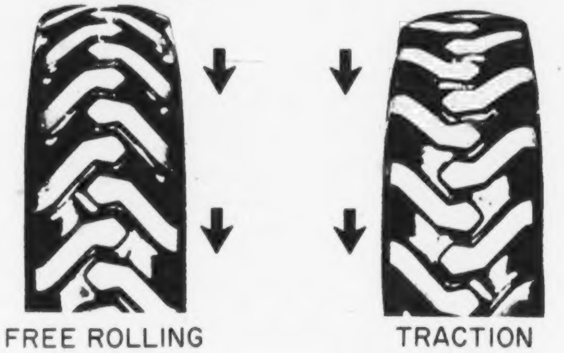


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Figure 5-37.—Directional tread tires.

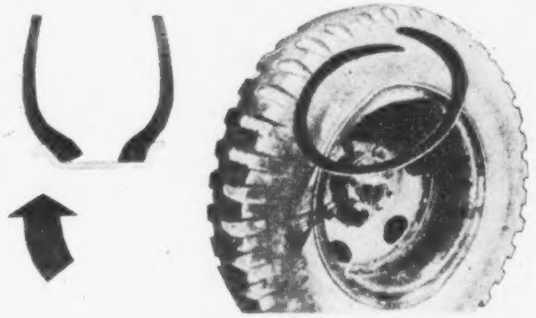

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Figure 5-38.—Rim damage.

the dirt and mud out to the side. When the directional tread tire is mounted on a towed vehicle or on a dead axle, it is mounted so that the open part of the "V" meets the ground first.

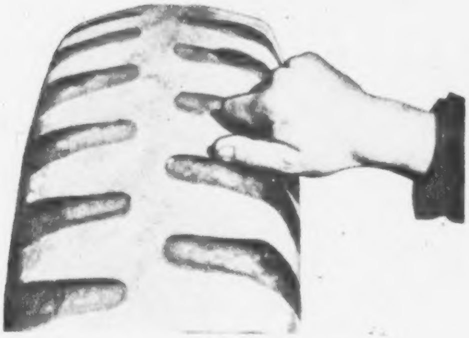
An insignificant little thing, but absolutely necessary, is the valve cap. This cover keeps dirt, water, and grit out of the valve and provides the final seal against air escaping from the tube. For speed and convenience in inflating, valve stems should be readily accessible. They should be positioned to prevent rubbing against the brake drum and to extend through the wheel hand holes. Ends of valves on front wheels and inside duals point away from the vehicle. Valves on outside duals point toward the vehicle. On dual wheels, valves are placed 180° apart for convenience in checking pressure and inflating.

Rims and rim flanges should be checked regularly to be sure that they are in good condition and fit properly. Since the flange comes in direct contact with the bead which supports the tire, flanges that are bent, broken, chipped, or of the wrong size, put a terrific strain on the bead and lead to early tire failure. (See fig. 5-38.)

Most of the larger wheels and rims used on equipment are the lockring type. The use of the lockring makes tire changing much easier and faster than on the one piece rim of the same size. The principle of the lockring is simple, requiring only that the lockring be firmly seated in the gutter of the rim base. When this is done, the tire and wheel will perform equally as well as the one piece rim. While there is a high safety factor built into the tire and rim assembly, danger results from carelessness or negligence in assembly. Before starting the inflate, make sure that all rim parts are correctly assembled and interlocking. It is recommended that inflation cages, safety chains, or some other safety device be used during inflation. Rims and lockrings should be inspected periodically for damage. A damaged rim or lockring should be replaced immediately as this will create a safety hazard and may ruin a tire. A displaced lockring may spring loose and can result in serious injury or death to personnel who may be in the vicinity.

When should we replace worn tires? This is a very important question because tires worn beyond the prescribed limit cannot be recapped. Illustrated in fig. 5-39 is a method that may be used as a guide to determine when a tire is approaching the replacement stage. If you cannot grip the tread with your thumb and index finger, ask your supervisor for technical assistance to determine if replacement is required. When the tread design is worn off in the center so that the tire is smooth across the center, the tire should be replaced.

Make careful checks for damage due to vehicle obstructions. Spring clips, fender bolts, exhaust pipes, etc., may be set in a satisfactory location when the vehicle is at a standstill. But under unusual operating conditions, the body movement may cause these units to contact the tire and cause severe abrasion. The tires of



81.508
Figure 5-39. — Replace worn tires.

low bed trailers and trailer mounted air compressors are highly susceptible to this type damage.

Rocks or dry caked mud should be removed from between dual assemblies as soon as possible. Extensive tire damage can also be caused by snow and ice packed between duals or under fenders and cross braces in winter operation. Any such materials coming in contact with tires while they are in operation can cause severe cuts or abrasions.

SAFETY (AUTOMOTIVE)

The mechanical condition of a vehicle may be perfect, but if the operator is not a careful driver, accidents will occur. The Technical Digest, a magazine published by the Naval Facilities Engineering Command, reports on an accident caused when a child ran from the front door of a house into the street directly into the path of an on-coming Navy vehicle. The vehicle was traveling at only about 10 miles per hour. It had just been through a PM inspection; it was in good mechanical condition. When braked, it could be stopped in a very short distance. However, a hedge along both sides of the walk leading to the house, together with other shrubbery close to the street, obstructed the driver's view. The driver saw the child too late. The child was struck by the vehicle — and killed.

While it may have been unavoidable, this accident does nevertheless underscore the importance of careful driving. Adjust the speed of your vehicle to driving conditions about you. PLAY IT SAFE. At the wheel of a vehicle YOU represent the Navy. Careful driving will reflect credit upon you as an Equipment Operator, and upon the Navy, which has trained you for this rating.

Driving on a Navy base subjects you to base regulations governing the operation of motor vehicles within that area. Outside the base you become subject to the motor vehicle code of the state and to the laws of the locality in which the base is located. Every foreign country also has motor vehicle statutes with which you are required to comply.

At each base you should be able to get a copy of the Navy Driver's Handbook (NAVFAC MO-403). Study it. This publication contains instructions for safe operation of Navy vehicles. Also at each base you should find copies of motor vehicle regulations which govern base personnel who operate motor vehicles. Study them also.

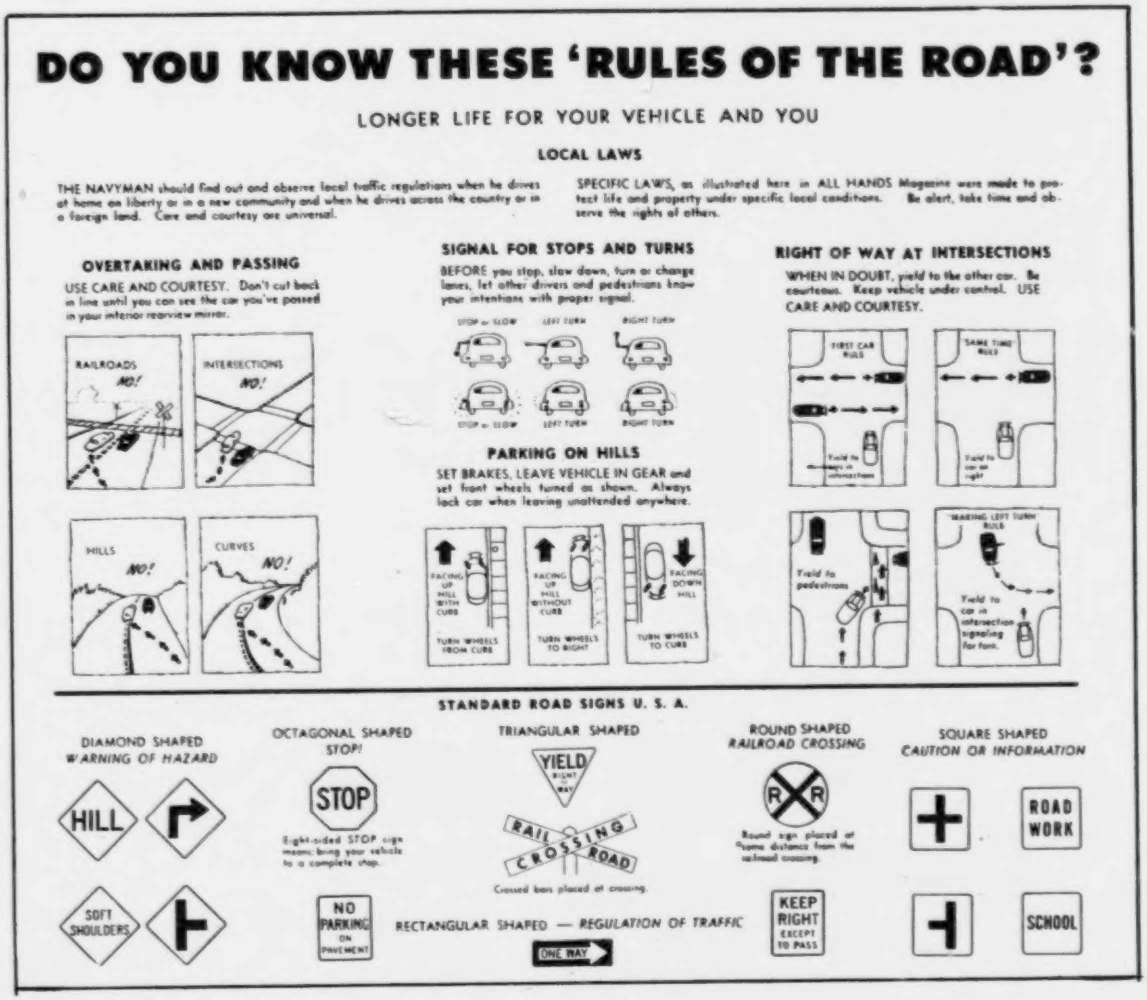
In addition, study figs. 5-40, 5-41, and 5-42, which provide a resume of safe driving practices, rules of the road, and road signs which could apply almost anywhere.

AUTOMOTIVE EQUIPMENT OPERATION

Operators of Navy vehicles are expected to practice "courtesy on the road" at all times towards other drivers, as well as towards pedestrians. Courtesy is a mark of the efficient and safe driver. The driver who practices courtesy on the road is helping prevent accidents with other vehicles and injuries to pedestrians.

You have probably seen many examples of discourtesy on the road. Common traits often displayed by the discourteous drivers include impatience, road hogging, excessive speed, and so forth. A person with such characteristics may have a lot of knowledge of driving, but it takes more than knowledge where safety is concerned. To achieve a good safety record, a driver must practice courtesy on the road at all times.

A courteous driver makes allowance for lack of skill and experience by other drivers. He also learns to recognize accident-producing situations far enough in advance to take action that



DO YOU KNOW THESE 'RULES OF THE ROAD'?

LONGER LIFE FOR YOUR VEHICLE AND YOU

LOCAL LAWS

THE NAVYMAN should find out and observe local traffic regulations when he drives at home on liberty or in a new community and when he drives across the country or in a foreign land. Care and courtesy are universal.

SPECIFIC LAWS, as illustrated here in ALL HANDS Magazine were made to protect life and property under specific local conditions. Be alert, take time and observe the rights of others.

OVERTAKING AND PASSING

USE CARE AND COURTESY. Don't cut back in line until you can see the car you've passed in your interior rearview mirror.

SIGNAL FOR STOPS AND TURNS

BEFORE you stop, slow down, turn or change lanes, let other drivers and pedestrians know your intentions with proper signal.

PARKING ON HILLS

SET BRAKES, LEAVE VEHICLE IN GEAR and set front wheels turned as shown. Always lock car when leaving unattended anywhere.

RIGHT OF WAY AT INTERSECTIONS

WHEN IN DOUBT, yield to the other car. Be courteous. Keep vehicle under control. USE CARE AND COURTESY.

STANDARD ROAD SIGNS U. S. A.

DIAMOND SHAPED *WARNING OF HAZARD*

OCTAGONAL SHAPED STOP!

Eight-sided STOP sign means: bring your vehicle to a complete stop.

TRIANGULAR SHAPED

Crossed bars placed at crossing.

ROUND SHAPED *RAILROAD CROSSING*

Round sign placed at some distance from the railroad crossing.

SQUARE SHAPED *CAUTION OR INFORMATION*

RECTANGULAR SHAPED — *REGULATION OF TRAFFIC*

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Figure 5-40.—Local laws and standard road signs.

CHECK YOURSELF

REST BEFORE a long trip. Refuse to drive when you are ill or fatigued.

AVOID ALCOHOLIC BEVERAGES. Drink strong coffee or tea to help stay alert.

PREVENT CARBON MONOXIDE poisoning by checking your exhaust system.

STOP AND REST!—Get out and walk around. Pull off road for a nap, if necessary.

CHECK YOUR VEHICLE

KNOW YOUR vehicle's history and keep a record of lubrication and repairs.

INSPECT CHASSIS for damaged springs, faulty shock absorbers, loose nuts, etc.

SEARCH FOR LEAKS of oil, water, gasoline. Inspect muffler for holes.

EXAMINE TIRES for uneven wear, damage and improper air pressure. Check spare.

BE SURE you have enough oil, water, gasoline, antifreeze and brake fluid.

CHECK ROAD AND WEATHER conditions that exist on your planned route.

ACCESSORIES —Try lights, horn, windshield wipers, heater and defroster. Adjust rear-view mirrors. Check tools.

KNOW YOUR ROUTE

GOOD ROAD MAPS will help you to familiarize yourself with turns and crossings, places to stop and type of roads.

FARM AREAS —Watch out for farm animals, crossings and agricultural vehicles.

PLAINS AND DESERTS —Monotonous long stretches of road may lull you to sleep or tempt you to speed. Check your supply of gas, water and oil.

INDUSTRIAL AREAS —Congested traffic will slow you down. Adopt defensive driving and forget "hurry."

RESIDENTIAL AND SCHOOL AREAS —Be alert for children playing, old folks, shoppers and pets. Obey speed limits. DON'T PASS A STOPPED SCHOOL BUS from either direction!

NIGHT DRIVING

GET PLENTY OF REST before a long trip.

DRIVE AT LOWER SPEEDS than in daytime.

AVOID LOOKING DIRECTLY at approaching headlights and use right-hand edge of road as your guide.

DEPRESS HEADLIGHTS when meeting another vehicle and when following another car.

KEEP HEADLIGHTS ADJUSTED and clean.

KEEP WINDSHIELD CLEAN for better vision.

CHECK BATTERY, lights, wiring and flashlight.

PRACTICE COURTESY!

ENGINE AS A BRAKE GOING DOWNHILL

Always drive down a hill with vehicle in gear. Brake gently to reduce speed, if necessary.

HAZARDOUS ROAD CONDITIONS

HEAVY RAIN—Keep lower beam headlights and taillights on. Drive slowly!

SLEET—If sleet accumulates too fast for defroster, pull over and don't drive—take "five."

FOG—Stay off the road unless trip is absolutely necessary . . . then CREEP!

Drive with LOWBEAM headlights.

Avoid sudden stops to prevent rear-end collisions.

SNOW AND ICE—Keep speed down.

Keep car pulling steadily with no sudden changes of direction or speed.

Follow other cars at longer distances.

Make no sudden use of brake.

Stay in gear to maintain control.

Steer in the same direction that the rear end is skidding.

Avoid oversteering. Keep both hands on wheel.

Keep windshield clean.

Start slowly and in higher gear.

Take *it* easy, even *with* chains.

WET LEAVES, OIL, DEEP BUMPS, MUD and LOOSE SAND can be treacherous! Slow down!

IF YOU RUN ONTO A SOFT SHOULDER

NEVER try to get back on the pavement at high speeds.

DON'T slam on the brakes.

DRIVE STRAIGHT AHEAD and slow your vehicle down *gradually*.

COME TO A STOP or slow way down.

DRIVE back onto pavement *slowly* and at a *sharp angle*.

IF A TIRE BLOWS OUT

KEEP OFF the brake and gas pedals.

STEERING IS THE IMPORTANT THING. Grip the wheel hard to keep the car on as straight a path as possible.

APPLY BRAKES GENTLY and slowly, keeping the car in gear until you stop.

CROSSING TROLLEY CAR TRACKS

ALWAYS drive off the tracks or straddle one rail. If you must cross, bring your car to a slow speed and cross *AT A SHARP ANGLE.*

BE SURE TO CHECK behind you and give proper signal for turn you will make.

IN CASE OF ACCIDENT

STOP immediately . . . and, if needed, RENDER FIRST AID and get medical help.

CALL POLICE (civilian or military) and notify your command.

PREVENT OTHER COLLISIONS by directing traffic, placing flares, clearing road.

IDENTIFY YOURSELF but don't sign anything.

MAKE REPORT to proper authorities and insurance company.

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Figure 5-41.—Safety checks.

will prevent them from happening. He is willing to give in to other drivers in such matters as yielding right-of-way rather than risk an accident. Among other things, the courteous driver is aware of his responsibilities, and shows proper respect for driving regulations and the rights of others.

The competent Equipment Operator who drives a motor vehicle is spotted by his businesslike and courteous attitudes, alert posture, and skilled performance behind the wheel. He handles the vehicle controls easily and smoothly. He always is aware of the position of his vehicle in relation to other traffic. He does not abuse the brakes, because he keeps a safe distance from the vehicle ahead and "plays" the traffic lights. He keeps the vehicle in the correct lane. In advance of all right and left turns he signals to keep everyone informed of his intentions. Very seldom does he have to make a sudden stop.

Safe Speed

In the law books, there are several statutes dealing with speed, but the basic one is simply the rule of common sense: NO PERSON SHALL DRIVE A VEHICLE ON A HIGHWAY AT A SPEED GREATER THAN IS REASONABLE AND PRUDENT UNDER THE EXISTING CONDITIONS. If you want to live, and want others to live, you will find no traffic law more important than this one.

Few of us are good judges of speed. Most of us have had the experience of attempting to slow down to 20 or 25 miles an hour, only to glance at our speedometers and find we were still traveling at 40 or 45 miles an hour. Our judgment of speed is relative. After we have been driving at one speed for some time, we get used to it. We are likely to think that we are going slow just because we have slowed down a little.

The "existing conditions" are constantly changing as you drive. One minute you are rolling along through open farm country. The next minute you are driving through a small road-side community. A few minutes later, you are passing through a school zone. Controlling your speed demands constant attention to changing conditions.

The conditions you should take into consideration in controlling your speed include not only the type of district, but also weather, light, sight distance, speed of other traffic, type of road surface, condition of your vehicle, and your own physical condition. Sight distance is especially important. You should always be able to stop your vehicle within the distance you can see ahead.

In addition to the "basic common sense" rule, there are maximum speed limits set by law. Speed limits are usually posted for the driver's information; however, to keep speed reasonable and prudent, it is often necessary to drive slower than the maximum limits but never faster, except as specifically authorized. Certain vehicles are allowed to exceed speed limits in specific situations.

The years have seen many improvements in the safety equipment of vehicles. Brakes have been made more effective, lights more powerful, and tires more dependable. Yet, it is as true today as it was 50 years ago that the most important safety equipment in any vehicle is the control which the driver has over the machine. The faster the vehicle goes, the more of that control the driver gives up, the less chance he has of avoiding an accident, and the more deadly an accident will be. Accident statistics show that speed is a factor in a fifth of all accidents and in almost half of the fatal accidents. It affects your ability to turn, pass, stop, and slow down. Nothing is more important to safe driving than careful control of your speed.

High speeds are much more dangerous than low speeds, but the driver who drives so slowly that he prevents other drivers from driving at a reasonable speed is also a serious traffic hazard. Where passing is difficult, the slow driver forces everyone else either to creep along behind him or to risk an accident in trying to get by. Very slow driving is especially dangerous just after you have passed the crest of a hill or rounded a curve because other drivers may crash into you before they can slow down. In many cases, the slow driver causes an accident that he himself escapes. If you find it necessary to drive slowly to get a better view of sights, locate an address, etc., park your vehicle, and thereby avoid endangering and irritating other drivers. In some areas, minimum speed limits are posted and these limits will be observed and obeyed with regard equal to that given maximum limits.

Where traffic conditions permit, keep your speed steady. The driver who, for no apparent

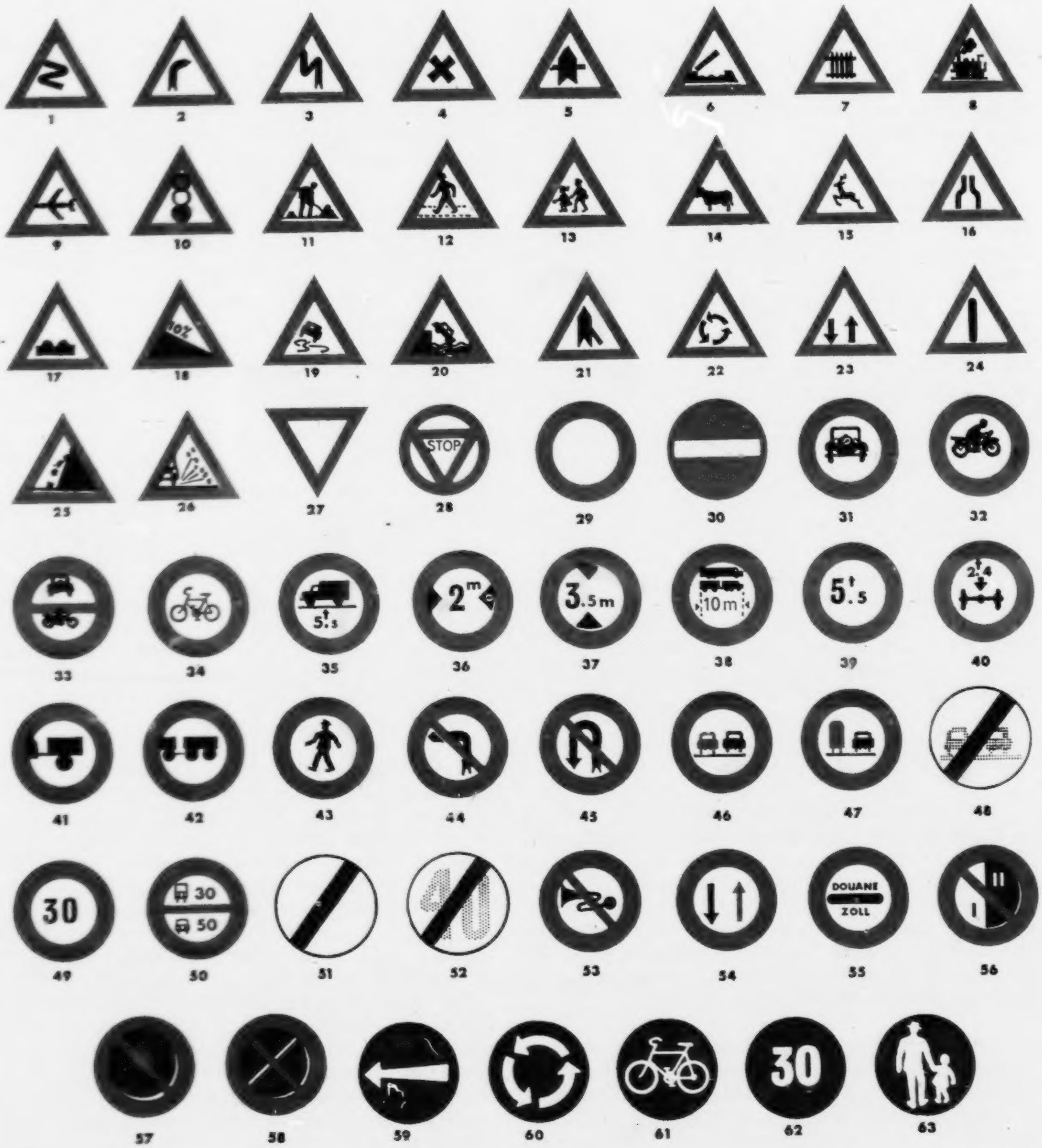

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Figure 5-42. — International road signs.

1 Dangerous bend
2 Right bend
3 Double bend
4 Intersection
5 Intersection with a non-priority road
6 Opening bridge
7 Level-crossing with gates
8 Level-crossing without gates
9 Low flying aircraft
10 Traffic signals ahead
11 Road works
12 Pedestrian crossing
13 Children
14 Beware of animals
15 Animals crossing
16 Road narrows
17 Uneven road
18 Dangerous hill
19 Slippery road
20 Quay or river bank
21 Merging traffic
22 Roundabout ahead
23 Two-way traffic
24 Danger
25 Danger from falling rocks
26 Loose chippings
27 Priority road ahead
28 Stop at intersection
29 Closed to all vehicles
30 No entry for all vehicles
31 No entry for all motor vehicles except motorcycles without sidecars
32 No entry for motorcycles without sidecars
33 No entry for all motor vehicles
34 No entry for pedal cyclists
35 No entry for goods vehicles exceeding...tons laden weight
36 No entry for vehicles having overall width exceeding...metres
37 No entry for vehicles having overall height exceeding ...metres
38 No entry for vehicles having overall length exceeding ...metres
39 No entry for vehicles exceeding...tons laden weight
40 No entry for vehicles having an axle weight exceeding...tons
41 Closed to all motor vehicles drawing a trailer other than a semi-trailer or a single-wheel trailer
42 Closed to lorries drawing a trailer
43 Closed to pedestrians
44 No left (or right) turns
45 No U turns
46 Overtaking prohibited
47 Overtaking by lorries prohibited
48 End of prohibition
49 Speed limit
50 Speed limits for light and heavy motor vehicles
51 End of speed limit
52 End of speed limit
53 Use of horn prohibited
54 Priority to be given to vehicles coming in the opposite direction
55 Stop: Customs
56 No parking – on left on uneven dates; on right on even dates
57 No parking
58 Stopping prohibited
59 Direction to be followed
60 Roundabout
61 Compulsory cycle track
62 Compulsory minimum speed
63 Compulsory way for pedestrians

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Nomenclature for figure 5-42.

reason, alternately speeds up and slows down confuses and endangers other drivers. With practice, you can keep your speedometer needle hovering close to the speed at which you intend to drive. A steady speed is not only safer, but more comfortable and economical.

Stopping Distance

As the speed of a vehicle increases, the distance required to stop increases at a much greater proportion. For example: a car traveling at 20 mph may stop within 43 to 47 feet, according to road conditions. But, at 60 mph, it will not stop in less than 251 feet, and may require up to 366 feet. Although the speed was tripled, the stopping distance, under ideal conditions, increased at least 5 times (fig. 5-43).

It takes a great deal more braking power and requires a much greater distance to slow a vehicle from 50 to 40 miles per hour than it does from 30 to 20 miles per hour. A careless driver, failing to recognize or properly understand this fact, may enter curves at too high a rate of speed or fail to maintain the proper interval between vehicles moving at high speeds. Vehicle brakes cannot be applied instantly. You may be surprised at the distance your vehicle will travel from the time you take your foot off the accelerator and depress the brake pedal until the brakes actually take effect.

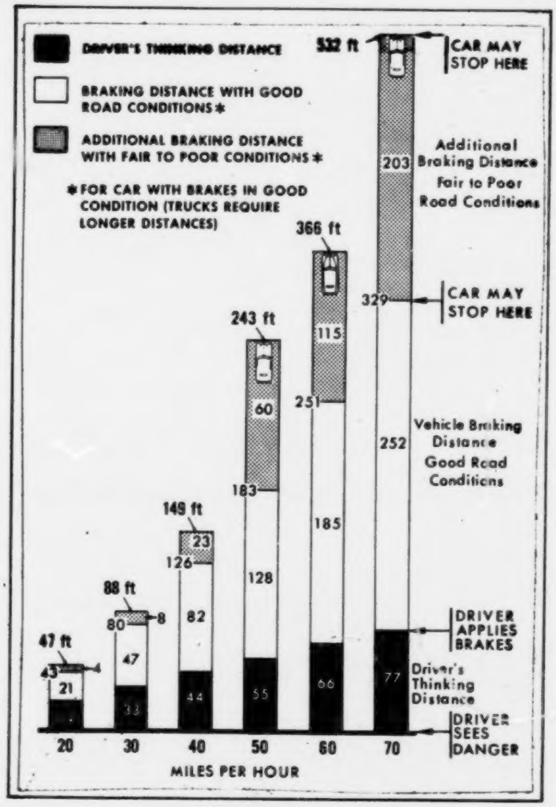

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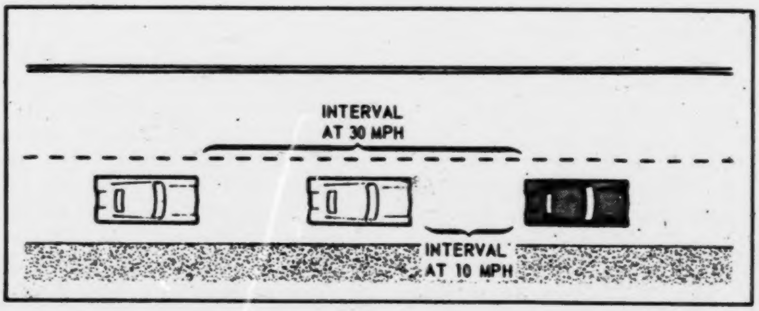
Figure 5-43. — Speed as a factor of stopping distance.

At 40 mph, the car travels 44 feet before the driver can react to danger and move his foot to the brake pedal (0.75 seconds). But, at 60 mph (1 1/2 times the previous speed), the car travels 66 feet.

Most rear-end collisions are caused by following too closely; this action is one of the four major causes of accidents. As shown above, the distance required to stop a car increases greatly as speed is increased. A guide for estimating safe distance when following another vehicle, at least at the lower speeds, is: Allow at least one car length between vehicles for every 10 mph you are traveling (fig. 5-44). The danger of rear-end collisions can be reduced by decreasing your speed, allowing sufficient space between your car and those ahead, and giving proper signals. The injuries to passengers and driver that result from such collisions can be reduced by consistent use of seat belts.

Road Clearance

Road clearance figures indicate the maximum space available for a vehicle to pass under or through a structure. Road clearance is posted at the approach to a tunnel, underpass, bridge, or other structure, or is marked on the structure itself. The road clearance required for a vehicle is (a) the total height of the vehicle and any part of the load which may extend above the vehicle, (b) the total width of the vehicle and any part of the load which may extend beyond its sides, and (c) the free space required to maneuver the vehicle and load. Usually, the word CLEARANCE on a sign indicates distance from the road to the overhead obstruction, while MAX WIDTH is used for the space between obstructions at the sides or between one side and oncoming traffic lanes.



115.434

Figure 5-44. — Proper intervals of following.

Determine the overall height and width of the vehicle and load before leaving on a trip. Be sure that the tires are inflated properly before getting the height; if considerable air is added to the tires, the overall height may be increased by several inches. Be sure that load tie-downs are properly secured; even if the load cannot break loose, the overall width may be increased if the load twists laterally on the truck. Write the height and width of the vehicle on a pad or the driver's log for reference during the trip.

In addition to the actual height and width, sufficient free space within specified height and width limitations is required to compensate for the constant up-and-down motion which occurs while operating the vehicle; similarly, a constant side-to-side compensation for the sway is required. Both the vertical and horizontal motion can be controlled by reducing the vehicle speed. However, the driver should allow several inches of free space for such maneuvering when he compares his vehicle and load with the posted clearance.

Fatigue Limits of Operator

Continuous driving frequently results in driver fatigue; that is, physical and mental tiredness due to sitting a long time at the wheel. If a driver is overtired, he may doze at the wheel, and if the vehicle should go out of control, a serious or fatal accident may occur.

As a safety measure, driver should take breaks or rest stops — when becoming fatigued or sleepy. After parking the vehicle, get out and walk around in order to stretch your muscles. Rest stops are especially important when on a long trip requiring many hours of driving.

Emergency Equipment

If an emergency breakdown occurs while you are away from your home station, move the vehicle off the road, even if it requires driving with a flat tire. If it is not possible to move the vehicle off the road, use emergency equipment such as flags to signal oncoming traffic to proceed with caution. Set out warning flags or markers; at night, set out kit reflectors or lighted flares (fuses). Do not attempt repairs while the vehicle is in an exposed position on the road. After making sure all safety precautions have been taken during an emergency, contact the nearest military activity for assistance.

If a breakdown occurs on your station, contact the dispatcher or supervisor by radio or telephone, or request a passing driver to make the call for you.

HANDLING, LOADING, AND HAULING

When hauling, loading, unloading, and hauling special cargo such as explosives, fuels, and other flammables, special care must be exercised. Improper handling of such materials may result not only in their malfunctioning later on, but also in serious, or even fatal, accidents.

During the loading of special cargo, ensure that the cargo is placed carefully in the vehicle and located so as to prevent sliding, falling, shifting, or spilling during transit.

Proper handling of special cargo during unloading operations will be carried on under the direction of the operator.

During loading and unloading operations of special cargo, the operator of the hauling vehicle, must ensure that:

1. The engine is shut off.
2. The hand brake is securely set, the wheels blocked, and the power unit is in the lowest forward or reverse gear.
3. No one smokes within 50 feet of the vehicle during loading and unloading of special cargo.
4. Firefighting equipment is available.

To ensure proper vehicle loading, no vehicle will be loaded beyond its rated capacity. Further, the load must not obscure the operator's view ahead or to either side, or in any way interfere with safe operation of the vehicle. Where a load overhanging the sides of a vehicle is transported within a shore activity, special precautions must be taken to prevent collision between overhang of the load and another vehicle. Minimum precautions should include walking flagmen or escort vehicles. Where overhanging loads are to be transported over the public highway, clearance must first be obtained from local civil authorities. If a civil police escort is not provided for the vehicle, the activity will provide an adequate escort.

Heavy loads must be properly distributed. Incorrect distribution may overload individual tires or axles even though the weight of the load is within the rated capacity of the vehicle.

The load of the vehicle should be so arranged that none of the cargo can drop, shift, leak, or otherwise escape. The load must be braced and stayed with proper lines, chains, dunnage or other fittings. The operator is responsible for the load and is authorized to refuse cargo that is improperly loaded. Side stakes and tailgates or end stakes of trucks and trailer must be installed securely in place whenever material or personnel are being transported. Header boards or similar devices of sufficient strength will be used where the cargo is of a type that would be likely to crush or penetrate the driver's compartment in case of too rapid deceleration or accident.

When loading a dump truck with a power shovel, clamshell, or other type of bucket, the driver will leave the driver's seat and remain out of reach of the dipper or bucket until the truck has been loaded, unless the dump body is provided with a shield adequate to protect the driver from bucket spills. When loading any truck, using a hook or in any situation where the bucket or boom must pass over the cab in loading, the driver should dismount and stand clear.

No vehicle hauling an unusually heavy load over a highway or within a municipality will be moved until the operator has been advised of the correct weight of the vehicle and load, and given specific insturctions as to the route which he is to follow (one which has previously been chosen as safe and legal).

Trucks or trailers, while carrying cargo, should not be used to transport personnel. Within government reservations, empty trucks may be used to transport small groups (less than 12 persons) of seated passengers for short distances. No part of any passenger's body should extend beyond the running lines of the truck or trailer.

One passenger may, at the discretion of the crew leader, be carried in the cab of a cargo-carrying vehicle.

Dump trucks should never be used to transport personnel.

DISPATCHING

The administration of transportation equipment matters at an activity should be the sole responsibility of a designed component of the activity. This component is usually called the Transportation Division, and in large activities, it is a part of the Public Works Department. In Mobile Construction Battalions, transportation functions are usually administered by "A" Company. In small activities the transportation functions are often administered by a transportation branch or section. Responsibility for the administration of the transportation division is assigned to one individual designated as the transportation officer. Important functions of your job as a dispatcher are to help the transportation officer carry out his responsibilities and help administer the transportation division. With this in mind, let us look at the transportation officer's job.

The transportation officer is responsible for the administration, operation, maintenance, and repair of all transportation equipment. The size of the activity naturally has a bearing on the number of personnel and the amount of equipment he has to help him to do this job. All the Equipment Operators should be carried on his rolls along with the dispatcher (normally an EO) and the mechanics (normally CMs). A transportation division organization chart showing the current size, makeup, personnel assignments, and functional relationship of the division should be properly displayed.

SETTING UP A MOTOR POOL

Careful planning is needed in setting up a transportation and heavy equipment motor pool. The pool to be established will depend on the size and mission of the activity as well as the terrain and the climatic conditions of the area. Realizing this, you can understand why there is no set of rules which can be used as a guide.

The Navy is well equipped with shore stations within the continental limits of the United States. You will find that motor pools have been well established at these stations. The chances are slight, therefore, that you will participate in the establishment of such pools in this country. At overseas activities however, it may be necessary for the SEABEES to develop a motor pool from scratch. The overall boss of the operation will undoubtedly be the transportation officer. Nevertheless, as a second or third class petty officer, you will be working very closely with the transportation officer and your chief petty officer, and you should have a knowledge of their responsibilities.

The first step in establishing a motor pool is a wise selection of the site. It must be near enough to the project or projects to be undertaken so that the equipment can be used economically and efficiently. Terrain conditions may not provide such a desired location and costly and slow excavation may necessitate a compromise. In choosing a site, the problem of drainage must be kept in mind. It may be possible to choose one site that will offer more natural drainage than another. Also, space requirements must be considered. A site should be selected that allows for expansion if the need arises. All these factors must be weighed by the transportation officer or the chief petty officer in consultation with the engineering officer before final selection of the site.

Space requirements of a motor pool will depend on the type, size, and the number of pieces of equipment to be accommodated in the pool. Ample space for parking should be provided as a safeguard against scraped fenders and other such accidents. If possible, the area should be large enough for parking arrangements that will allow access to a particular vehicle without having to move several others.

In some climates, adverse weather conditions—such as heavy rains or snowfalls—may necessitate construction of extensive drainage structures in the pool area. During the rainy season at some overseas bases, poor drainage may cause vehicles to become stuck in mud and unable to leave the pool. Therefore, the importance of drainage must not be overlooked.

The entrances and exits to the motor pool should be laid out to afford a smooth flow of traffic. They should be well marked and of ample width to accommodate the largest equipment. Traffic signs should be placed about the area as needed.

The extent of maintenance required for a motor pool area depends upon the type of base upon which the pool is located. You will probably find that motor pools at stations in this country have concrete bases. This type of base will not require frequent maintenance. However, at overseas and advanced bases you will find that most of the motor pools are made from material procured locally. The continuous flow of heavy equipment over these areas will soon result in an extremely rough surface. If the surface is allowed to remain in that condition, the equipment will be subject to more wear and tear than is necessary. This type of area should receive frequent maintenance which will consist mostly of filling, smoothing, and grading.

In climates with little or no rainfall, it is wise to wet down the area when dust becomes heavy. Control of the dust will save maintenance costs on the equipment. If one is available, a magnetic sweeping unit should be operated over the area at frequent intervals. This will save the tires of the vehicles. Maintenance of the pool area cannot be overemphasized since it means added savings in repairs and maintenance costs of the vehicles.

Vehicle arrangement is an important phase of motor pool operations. It is a good idea to group vehicles by type; that is, all the jeeps in one group, all the dump trucks in another, and so on. If this is done you, as a dispatcher, will be able to scan the area at any time and tell what vehicles are available. You may also designate an area of the pool for parking very heavy construction equipment. In this area you will need a ramp for loading crawler-type equipment onto a lowboy trailer.

In designating the area for the various groups, it is well to take into consideration the number of daily requests that may be expected for each type of equipment. Place those that will be making frequent short runs near the dispatch office. This will save your operator's walking time.

At all motor pools, security is of utmost importance. The area should be well lighted at night, if conditions warrant. At a remote location, a security watch should be posted. This watch should be a roving patrol.

Keep in mind that setting up a motor pool is an important task. Although the burden of establishment falls mostly on the transportation officer and the chief petty officer, don't fail to pass on any knowledge you may have acquired from experience that would have a bearing on the efficiency of operations.

DUTIES OF A DISPATCHER

In most cases, you will take over a dispatching job where the office is already established. There may be some changes that you may want to make to improve operation. The office should have a map of the area, a desk, and a phone.

In large activities it may be necessary to have more than one phone to handle the flow of messages.

The dispatcher's office and equipment pool should be located at a central location near the most frequently serviced points. A drivers' ready room should be adjacent to the dispatching office so that you can easily control and supervise the operators. Remember, this is a business office, and it must be run accordingly.

In very small operations, it is possible that dispatching may be only a part-time job, but usually it will be a full-time responsibility. To be an efficient full-time dispatcher, you must have certain qualifications. Let's look at the main ones.

You must be familiar with the local area, including the location of principal points to which it will be necessary to dispatch vehicles. Familiarity with local laws and regulations governing the use of equipment is a must. You should have a good knowledge of the local public transportation systems, their schedules and routes, as well as the regularly scheduled Government or military transportation in the area.

You should be able to make decisions quickly about matters that are on your level of responsibility, and to work efficiently under pressure. Some familiarity with clerical practices and with the way to maintain simple records will be helpful.

The ability to convey information and instructions to others in a concise and understandable manner is a qualification required of every good dispatcher.

The dispatcher controls the automotive pool operation in accordance with general policies and directives of the Navy and in accordance with local policies as directed by the transportation officer. The duties of a dispatcher are wide and varied. It would be impossible to cover them all in a short discussion. We shall describe a few problems that may arise in connection with dispatching duties and give some possible solutions.

One of the first things you should do when you take over as a dispatcher is to become thoroughly familiar with your equipment. To dispatch efficiently you must know the make, model, body type, capacity, and Navy identification number of all the equipment working out of your office. You would not want to send a 5-ton truck on the guard mail run, nor would you want to send a jeep to the skipper—at least, not if more suitable vehicles were available.

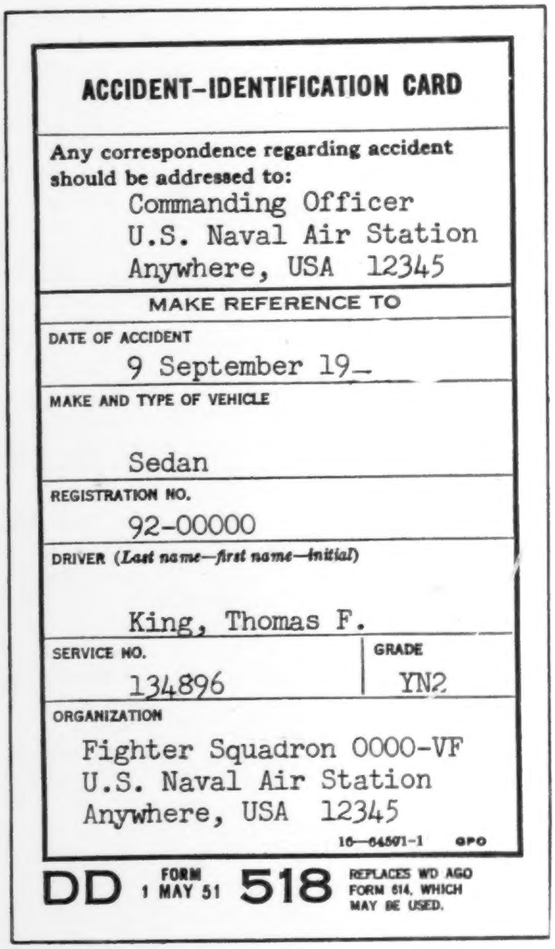
As soon as possible, get acquainted with your drivers. All of them will not have equal skill. Try to place each man on the job for which he is best suited. If Jones can drive a station wagon well, and Smith has had a lot of experience on heavy trucks, give Smith the heavy trucks and assign Jones to the station wagon. This does not mean that training is out. See that your men receive training in driving different types of vehicles and equipment, but do this training at scheduled intervals or when business is slack. Never permit a learner to operate any piece of equipment on his own until he is fully qualified, and is granted authorization on a U.S. Government Motor Vehicle Operator's Identification Card, Standard Form 46 (view A, fig. 5-45). Types of equipment for which a man is qualified and authorized to operate are listed on the reverse side of Standard Form 46 (view B, fig. 5-45). This form must be endorsed by the qualifying official. When a man becomes qualified, rotate assignments when conditions permit so that he will have the opportunity to develop his newly acquired skills.

You will soon learn who are the really dependable operators. They will always return on time; you will not get unfavorable reports on them; and their equipment will need fewer repairs.

You may be assigned to duty in a location with which you are not familiar. You will have to learn your way around as soon as possible. You will not always have experienced operators. Unless you know your way around, you will not be able to give directions to new operators. Make it your first order of business to learn the layout.

Besides knowing the general details of the most frequently traveled routes, you should have specific knowledge of certain details such as weight limits on certain roads and bridges, low clearance viaducts, and traffic hazards.

You will have to know the traffic laws of the states or country in which you are located. Most



ACCIDENT-IDENTIFICATION CARD

Any correspondence regarding accident should be addressed to:

Commanding Officer
U.S. Naval Air Station
Anywhere, USA 12345

MAKE REFERENCE TO

DATE OF ACCIDENT: 9 September 19_

MAKE AND TYPE OF VEHICLE: Sedan

REGISTRATION NO.: 92-00000

DRIVER (*Last name—first name—initial*): King, Thomas F.

SERVICE NO.: 134896

GRADE: YN2

ORGANIZATION:

Fighter Squadron 0000-VF
U.S. Naval Air Station
Anywhere, USA 12345

16—64501-1 GPO

DD FORM 1 MAY 51 518 REPLACES WD AGO FORM 614, WHICH MAY BE USED.

115.45

Figure 5-45.—U.S. Government Motor Vehicle Operator's Identification Card, Standard Form 46.

states have laws that require special permits for moving heavy equipment on the public highways. In California, for example, such permits are obtained from the State Highway Commissioner. If you were located in California, you would need a permit for any vehicle that is overweight, slow-moving, wider, longer, or higher than normal highway vehicles. Management of Transportation Equipment, NAVFAC P-300, lists weight and size limits for all states. Check the listing in this publication if there is any question of the regulation regarding the weight or size of a vehicle in a particular state.

The naval activity to which you are attached will have regulations regarding traffic and moving of heavy equipment. If you do not have a copy of these regulations, have your chief get you one. See that your operators read and become familiar with all regulations pertaining to equipment operations.

The moving of explosives is dangerous under the best of circumstances. Be sure that you comply with local and station regulations in regard to obtaining proper permits and police escorts.

Any time that you need to use public highways for slow-moving vehicles or large convoys of trucks notify the local police or highway authority as a matter of courtesy, even though it is not required by law or regulation.

Not only do you have to be sure your vehicles meet Navy requirements, but you must also ensure that they meet requirements established by the locality in which you operate. Study the Motor Vehicle Code for the state in which you are located. Before you dispatch a vehicle, make certain it meets local requirements as to lights, signals, and weight limits per tire.

Typical Day

Your routine will depend on the dispatching office in which you work and the equipment you are dispatching. Let's look at a typical day in a dispatching office.

When you come on the job in the morning, check the vehicles over for any damage that has not been reported. As you enter the office, check the key case to see that all vehicles are in or accounted for.

First, dispatch vehicles to the equipment garage that are due for a PM (preventive maintenance) check. Check the list of the regularly assigned vehicles for PM due. The PM clerk will notify you approximately 1 week in advance as to when a vehicle is due for a PM check. If for some reason you cannot send a vehicle to the garage for service, notify the PM clerk and have him reschedule the vehicle. PM is a very important function of the transportation division but the PM schedule can be flexible enough to allow you to handle emergency trips. To avoid unnecessary rescheduling of PM's, use substitute equipment when possible.

Regularly assigned vehicles will include the commanding officer's car, the ambulance, and the security vehicles.

There are certain vehicles which make regular runs, and these must be dispatched daily. Regular runs will be for guard mail, commissary supplied, garbage, and the like. Trip tickets (described later) for vehicles making such runs should be prepared before the scheduled time of the run so as not to cause undue delay in getting under way. The same applies to those vehicles which are assigned daily to certain units or activities of the station. Usually these trip tickets are made up the night preceding the morning of dispatch. When this procedure is followed, there is less confusion in the morning, when the height of activity at the motor pool occurs.

You may have some requests that were phoned in the day before, asking for a vehicle at a certain time. If trip tickets were not prepared at the time these requests were made, make them up before the time of the trip.

The rest of the day you will answer the phone, dispatch vehicles in response to requests, and take care of the necessary paperwork.

Before dispatching a vehicle on an extended trip, check to see that it is in good condition and that it is supplied with a spare tire and emergency equipment and tools. Issue the operator credit cards so that he can get gasoline and oil at commercial gas stations if this should be necessary. Use of commercial credit cards is explained in NAVDOCKS P-300. If any of your operators do not thoroughly understand the use of commercial cards have them check this publication.

If you are a dispatcher with a SEABEE activity engaged in construction work, you probably will dispatch vehicles on a priority basis. The various construction projects usually are assigned a priority by the transportation officer or the operations officer, and the vehicles, in turn, are assigned to the projects according to the respective priority of the project. That is, if there were requests for the same piece of equipment from two or more projects, the piece of equipment would be assigned to the project with the highest priority. If, on the other hand, you are a dispatcher at a naval station, you may not have a priority system on which to base your assignments.

Dispatching is often merely using common sense, plus courtesy and tact. Suppose you have two calls for transportation but only one vehicle available for dispatch. Common sense would tell you to send the vehicle on the most urgent trip. If each person seems to think that his trip is urgent, you will have to explain the situation to both people involved and try to resolve the situation, or you may be able to combine the trips. At times it may be necessary to call on higher authority to make a decision in such matters.

When a vehicle is requested, specify if possible the exact time that the vehicle will be available. Then have the vehicle at the place where you have promised that it will be and at the time agreed upon. Waiting is something that many persons have not learned to do calmly.

Be courteous and respectful when answering the telephone. The information concerning the transportation request should be as complete as possible. You must know who is requesting the transportation, where the trip is to start, and the time the trip is to start. If possible you should get the following additional information:

Where the trip is to end.
Number of personnel requiring transportation.
Amount and nature of materials to be hauled. (if any).
Whether a return trip is required.
Approximate duration of trip.

Related Duties

Your responsibilities do not end with dispatching vehicles or equipment; there are a number of duties that are related to the actual dispatching for which you are also responsible. You must log all trips as well as receive and process telephone and memorandum requests for transportation.

Cleanliness of the drivers' waiting room and dispatch office is your responsibility along with maintaining order and discipline in the transportation spaces.

You must know the whereabouts of all the vehicles assigned to the pool and also know where the personnel are who are assigned as vehicle drivers.

It is good practice to obtain the keys from the operator upon the conclusion of each assigned trip. You should make a personal inspection of all pool vehicles at the close of the working day to make certain that none of the equipment was involved in an accident that was not reported. While making this inspection you can ensure that no keys have been left in the vehicles.

Make sure that the drivers are in the proper uniforms for the jobs that they are going to do. In most cases it is a good policy to have the operators of passenger-carrying vehicles wear the prescribed uniform of the day; operators of nonpassenger-carrying vehicles are generally permitted to wear the working uniform. In all cases, make sure the uniforms are clean and neat. Remember, operators of pool vehicles will be seen by many persons during the course of a day and their appearance will reflect directly upon the transportation division.

DUTY DISPATCHER

Transportation dispatching duties do not generally end with the close of the normal working day. Remember, transportation is primarily a service and support function, and it may be needed around the clock in order to support the rest of the activity to which you are assigned.

When you become an Equipment Operator 3 or 2 you may be assigned the job as duty dispatcher on the days your section has the duty. You will carry on the work of the regular-dispatcher after normal working hours. Generally, the requests for transportation after hours will have been processed during normal working hours by the regular dispatcher. Your job will be to assign a driver from the duty section and see that he carries out the orders as prescribed.

You will be required to process any transportation requests that are made after normal working hours, and you must be certain that all requests are for official business in accordance with Navy policy and local regulations.

During nonworking hours, you will be responsible for seeing that the transporation spaces are kept clean and orderly.

In nearly every case, there will be a set of instructions to guide you in regard to your duties. These instructions are generally made up by the chief and approved by the transportation officer.

Unusual circumstances or transportation requests may arise that are not covered by your instructions. It will probably be up to you to make decisions regarding such cases. Be careful in making these decisions and do not overstep the bounds of your authority. If in doubt, check with the duty officer.

RECORDS AND REPORTS

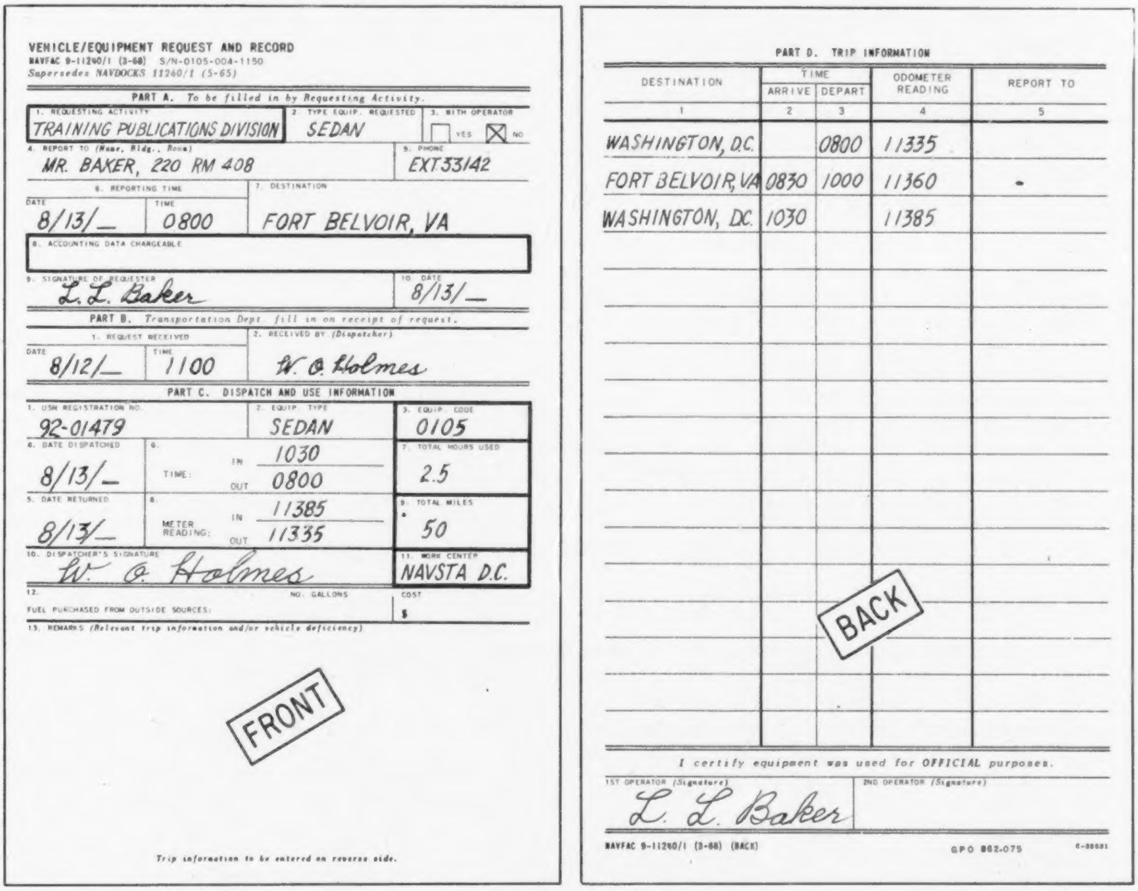
Almost everyone in the Navy complains about the amount of paperwork required. When a person gets paid, goes on leave, takes an examination, or does any one of dozens of other things, he must fill out a form of some kind. Do not be guilty of complaining about paperwork. There is a sound reason for every form used, and it will do the job intended only if properly filled out. If the Navy is to function efficiently, it is necessary to establish procedures. Forms used for records and reports are tools used to execute these procedures.

As you advance in rating, you will find your duties will become more and more supervisory and administrative in nature. You will manage jobs, direct the execution of orders, and apply rules and regulations. In doing these things, you will have to fill out records and reports. Let's take a look at some of these.

(NOTE: Some NAVFAC forms are identified by the term "NAVDOCKS" followed by the form number. This is due to a change in name of the activity which is not yet reflected on all forms. So remember that the two identifying terms refer to the same numbered form.)

DISPATCHING FORMS

The dispatch office is a very important part of a transportation pool. Since you as a Third- or Second-Class Equipment Operator will be required to handle dispatching duties, it is your responsibility to see that your maintain dispatching forms and records in the proper manner and in accordance with publications and directions. Some of the more common forms of concern to the dispatcher and operator are described in this section.



VEHICLE/EQUIPMENT REQUEST AND RECORD
NAVFAC 9-11240/1 (3-68) S/N-0105-004-1150
Supersedes NAVDOCKS 11240/1 (5-65)

PART A. *To be filled in by Requesting Activity.*

1. REQUESTING ACTIVITY: TRAINING PUBLICATIONS DIVISION
2. TYPE EQUIP. REQUESTED: SEDAN
3. WITH OPERATOR: ☐ YES ☒ NO
4. REPORT TO (*Name, Bldg., Room*): MR. BAKER, 220 RM 408
5. PHONE: EXT 33142
6. REPORTING TIME: DATE 8/13/__ TIME 0800
7. DESTINATION: FORT BELVOIR, VA
8. ACCOUNTING DATA CHARGEABLE
9. SIGNATURE OF REQUESTER: L. L. Baker
10. DATE: 8/13/__

PART B. *Transportation Dept. fill in on receipt of request.*

1. REQUEST RECEIVED: DATE 8/12/__ TIME 1100
2. RECEIVED BY (*Dispatcher*): W. O. Holmes

PART C. DISPATCH AND USE INFORMATION

1. USN REGISTRATION NO.: 92-01479
2. EQUIP. TYPE: SEDAN
3. EQUIP. CODE: 0105
4. DATE DISPATCHED: 8/13/__
5. DATE RETURNED: 8/13/__
6. TIME: IN 1030 OUT 0800
7. TOTAL HOURS USED: 2.5
8. METER READING: IN 11385 OUT 11335
9. TOTAL MILES: 50
10. DISPATCHER'S SIGNATURE: W. O. Holmes
11. WORK CENTER: NAVSTA D.C.
12. FUEL PURCHASED FROM OUTSIDE SOURCES: NO. GALLONS COST $
13. REMARKS (*Relevant trip information and/or vehicle deficiency*)

FRONT

Trip information to be entered on reverse side.

PART D. TRIP INFORMATION

DESTINATION	TIME		ODOMETER READING	REPORT TO
	ARRIVE	DEPART		
1	2	3	4	5
WASHINGTON, D.C.		0800	11335	
FORT BELVOIR, VA	0830	1000	11360	
WASHINGTON, D.C.	1030		11385	

BACK

I certify equipment was used for ***OFFICIAL*** *purposes.*

1ST OPERATOR (*Signature*): L. L. Baker
2ND OPERATOR (*Signature*)

NAVFAC 9-11240/1 (3-68) (BACK) GPO 862-075

29.51

Figure 5-46.—Vehicle/Equipment Request and Record, NAVFAC 9-11240/1, front and back.

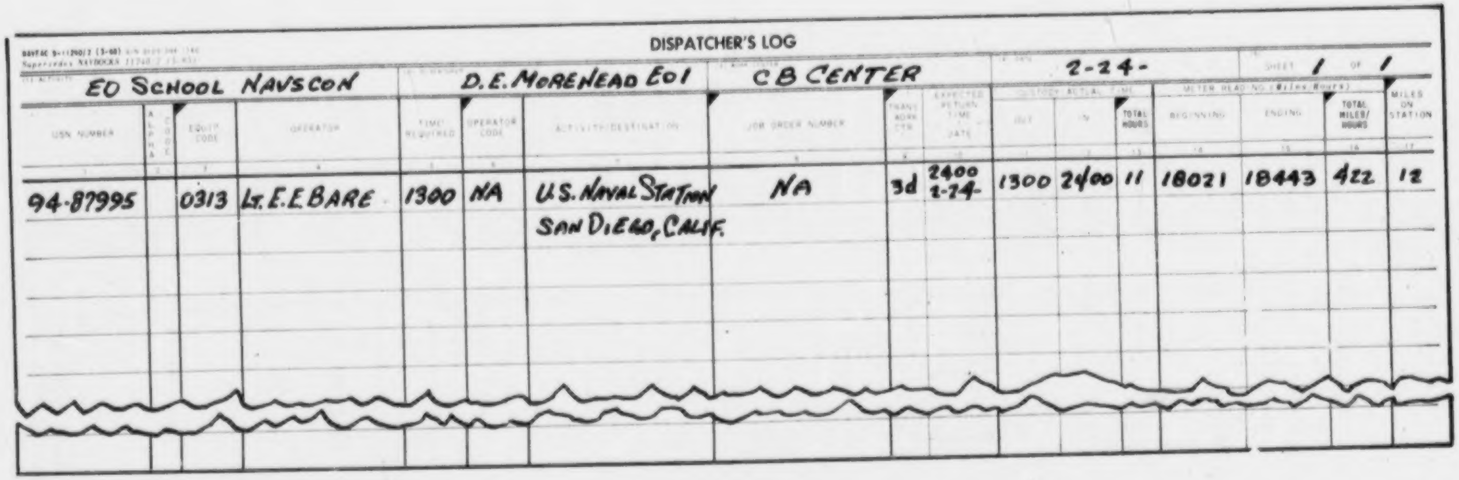
Vehicle/Equipment Request and Record

When properly filled out and signed by the dispatcher, the Vehicle/Equipment Request and Record, NAVFAC 9-11240/1 (fig. 5-46) is a driver's official authorization to operate a vehicle whether it be self-driven by the requester or driven by a pool operator. This form is commonly called the Trip Ticket. When completed, it contains a record of the operator's destination, time of departure and arrival, load, speedometer reading, and other information pertinent to the trip(s). When an operator turns in his NAVFAC 9-11240/1 you should look it over and make sure it is properly filled out and signed. This is your record to show the vehicle was an official trip.

Dispatcher's Log

As dispatcher, it is your job to see that the Dispatcher's Log, NAVFAC 11240/2 (fig. 5-47), is properly kept. Every trip must be logged before a vehicle is dispatched. Some data on the form cannot be included until the vehicle returns from the trip.

This log sheet, when properly filled in, gives you a ready reference as to the whereabouts of all the vehicles you have dispatched. It contains most of the information that is on the Vehicle/Equipment Request and Record.



NAVFAC 9-11240/2 (3-68)
Supersedes NAVDOCKS 11240/2

DISPATCHER'S LOG

ACTIVITY: EO SCHOOL NAVSCON
DISPATCHER: D.E. MOREHEAD EO1
WORK CENTER: CB CENTER
DATE: 2-24-
SHEET 1 OF 1

USN NUMBER	ALPHA CODE	EQUIP CODE	OPERATOR	TIME REQUIRED	OPERATOR CODE	ACTIVITY/DESTINATION	JOB ORDER NUMBER	TRANS WORK CTR	EXPECTED RETURN TIME DATE	CUSTODY ACTUAL TIME OUT	CUSTODY ACTUAL TIME IN	TOTAL HOURS	METER READING (Miles/Hours) BEGINNING	METER READING (Miles/Hours) ENDING	TOTAL MILES/HOURS	MILES ON STATION
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
94-87995		0313	Lt. E.E. BARE	1300	NA	U.S. NAVAL STATION SAN DIEGO, CALIF.	NA	3d	2400 2-24-	1300	2400	11	18021	18443	422	12

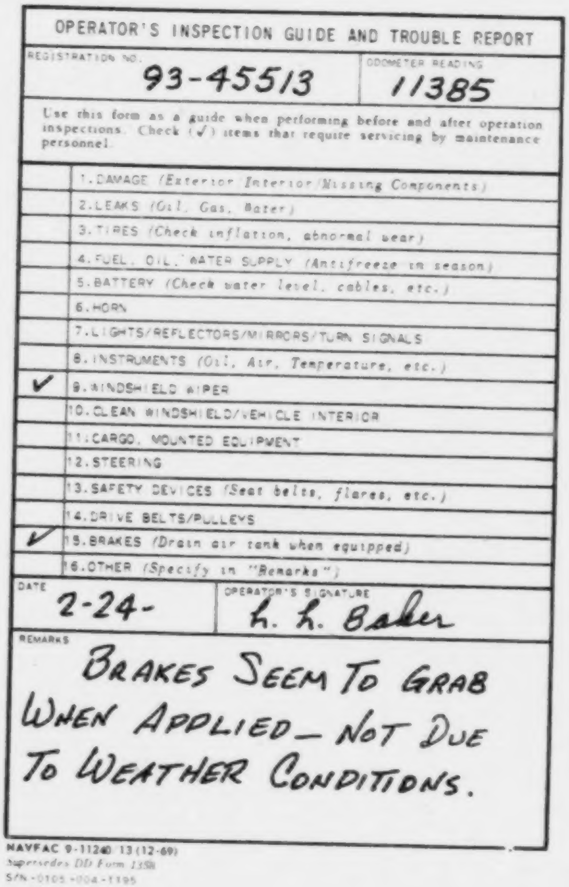
115.183

Figure 5-47.—Daily Dispatching Record of Motor Vehicles, NAVFAC 9-11240/2.

Operator's Inspection Guide and Trouble Report

The Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13 (fig. 5-48), is a guide for operator's maintenance. This form, commonly referred to as the Operator's Trouble Report, provides a uniform list of services to be performed by the operator before, during, and after operation.

The operator indicates by a check mark any item that does not function properly. The "remarks" space may be used for items not listed or for additional information concerning deficiencies indicated by a check mark. When this form is properly completed and turned in to the dispatcher, he can tell by looking at it whether the vehicle is ready for another job, or whether there is some repair work that must be performed on it. Local instructions will generally describe the procedures to follow in case the vehicle must be repaired.



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT

REGISTRATION NO. 93-45513

ODOMETER READING 11385

Use this form as a guide when performing before and after operation inspections. Check (✓) items that require servicing by maintenance personnel.

	1. DAMAGE *(Exterior Interior/Missing Components)*
	2. LEAKS *(Oil, Gas, Water)*
	3. TIRES *(Check inflation, abnormal wear)*
	4. FUEL, OIL, WATER SUPPLY *(Antifreeze in season)*
	5. BATTERY *(Check water level, cables, etc.)*
	6. HORN
	7. LIGHTS/REFLECTORS/MIRRORS/TURN SIGNALS
	8. INSTRUMENTS *(Oil, Air, Temperature, etc.)*
✓	9. WINDSHIELD WIPER
	10. CLEAN WINDSHIELD/VEHICLE INTERIOR
	11. CARGO, MOUNTED EQUIPMENT
	12. STEERING
	13. SAFETY DEVICES *(Seat belts, flares, etc.)*
	14. DRIVE BELTS/PULLEYS
✓	15. BRAKES *(Drain air tank when equipped)*
	16. OTHER *(Specify in "Remarks")*

DATE 2-24-

OPERATOR'S SIGNATURE L. L. Baker

REMARKS

BRAKES SEEM TO GRAB WHEN APPLIED—NOT DUE TO WEATHER CONDITIONS.

NAVFAC 9-11240/13 (12-69)
Supersedes DD Form 1358
S/N-0105-004-1195

29.50

Figure 5-48.—Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13.

When no troubles are indicated, the Operator's Trouble Report may be destroyed.

Operator's Daily PM Report, Construction and Allied Equipment

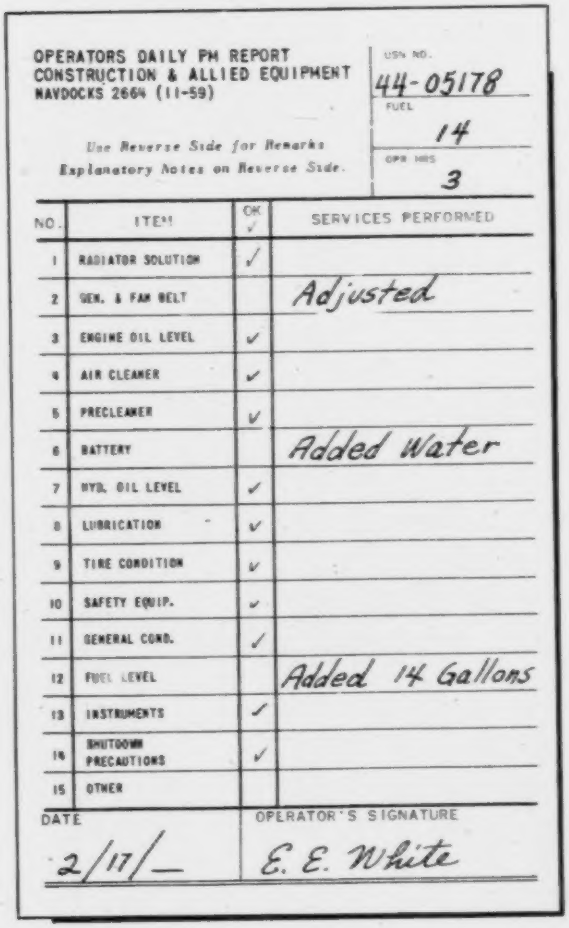
The Operator's Daily PM Report—Construction and Allied Equipment, NAVDOCKS 2664 (fig. 5-49), is issued to the operator when construction and allied equipment is assigned.

You will perform pre-service maintenance checks of the items listed indicating findings in an appropriate space on NAVDOCKS 2664. Record malfunctions of other items requiring attention as observed during the working day; show the number of gallons of fuel issued to your equipment; and enter hours operated during the day. Hour readings will be taken from the equipment hour-meter. Actual operating hours will be estimated for those units not equipped with hour-meters.

After securing your equipment, turn NAVDOCKS 2664 in to the dispatcher, who will review it to ensure that the entries recorded are valid and to take note of any deficiencies. The form is then forwarded to the maintenance shop for processing.

Have the operators turn in a NAVDOCKS 2664, completely filled out, at the end of each day.

NAVFAC 9-11240/13 and NAVDOCKS 2664 are both important reports that are an essential part of the maintenance program. The operator of equipment has a better opportunity than anyone else to discover defects before they become serious. Reporting such defects on the proper forms gives the repair shop personnel a chance to correct them at an early stage. Be certain to report any operating difficulty that you encounter during your daily work with vehicles and equipment.



OPERATORS DAILY PM REPORT
CONSTRUCTION & ALLIED EQUIPMENT
NAVDOCKS 2664 (11-59)

Use Reverse Side for Remarks
Explanatory Notes on Reverse Side.

USN NO. 44-05178
FUEL 14
OPR HRS 3

NO.	ITEM	OK ✓	SERVICES PERFORMED
1	RADIATOR SOLUTION	✓	
2	GEN. & FAN BELT		Adjusted
3	ENGINE OIL LEVEL	✓	
4	AIR CLEANER	✓	
5	PRECLEANER	✓	
6	BATTERY		Added Water
7	HYD. OIL LEVEL	✓	
8	LUBRICATION	✓	
9	TIRE CONDITION	✓	
10	SAFETY EQUIP.	✓	
11	GENERAL COND.	✓	
12	FUEL LEVEL		Added 14 Gallons
13	INSTRUMENTS	✓	
14	SHUTDOWN PRECAUTIONS	✓	
15	OTHER		

DATE 2/17/—
OPERATOR'S SIGNATURE E. E. White

81.323
Figure 5-49.—Operator's Daily PM Report Construction and Allied Equipment, NAVDOCKS 2664.

In addition to the operational checks and reports by the Equipment Operator, vehicles will be inspected periodically by qualified automotive inspection personnel for safety and serviceability at intervals not to exceed 6 months or 6,000 miles, whichever occurs first.

Each activity will prepare preventive maintenance procedures for equipment in the same format as for motor vehicles except the frequencies may be established in operating hours. The data for these procedures will be obtained from the manufacturer's maintenance manual provided with the equipment.

Operator's Report of Motor Vehicle Accident

Every accident involving a Navy motor vehicle or item of construction equipment must be reported by the operator on Standard Form 91, Operator's Report of Motor Vehicle Accident. (See fig. 5-50.) Copies of this form and a pencil should be carried in every Navy vehicle at all times. In case of an accident involving another vehicle, this report must be made, even if the driver of the other vehicle states that no claim will be filled for damages, or no matter how unfavorable the circumstances of the accident may be to the Navy. The report must also be made in the case of an accident not involving another vehicle. The operator involved in an accident must deliver the accident report, or ensure its immediate delivery, as soon as possible, to his supervisor, who must forward it to the motor accident investigating officer of the battalion.

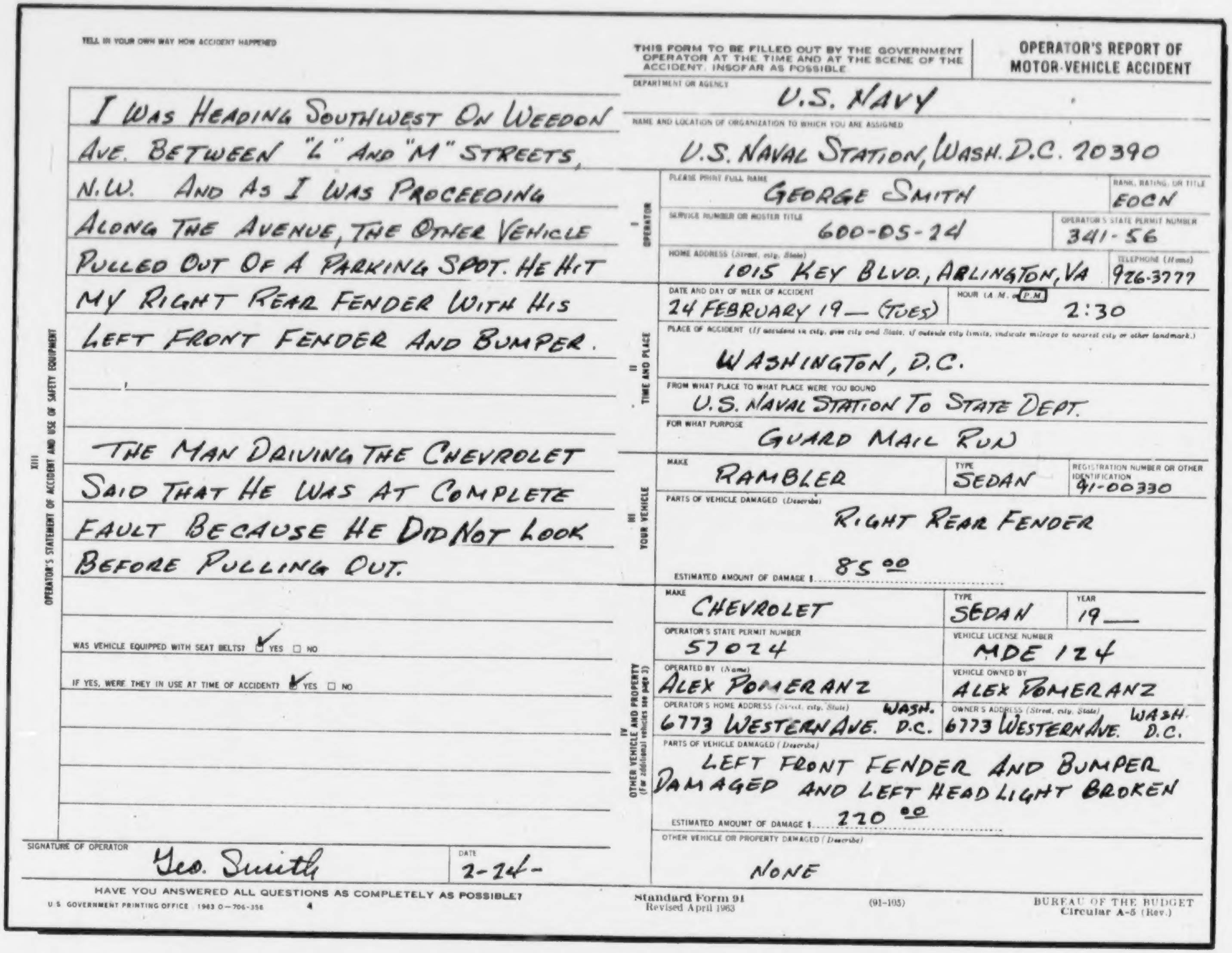
If involved in an accident, your first responsibility is to render aid to the injured. After they have been cared for, proceed to complete the accident form. As an aid in completing Standard Form 91, the following general instructions are given:

Obtain and properly spell names and street addresses of persons involved in the accident and all witnesses.

Carefully note weather conditions, road conditions, position of the vehicle involved, and any other such details which you cannot get later.

Be sure that your report gives a clear picture of what actually happened. Your diagram of the accident should show exactly where the vehicles were before and after the accident.

State damage you can see, such as "crushed right rear wheel or crumpled fender," and give an estimate of the amount of damage. If someone claims that he has damaged property but you cannot see the damage, note on the accident form only that he "claims bent fender," etc. Follow the same procedure with injuries. Report cuts, burns, broken bones, etc., of which you are certain, and note only that a person



OPERATOR'S REPORT OF MOTOR-VEHICLE ACCIDENT

THIS FORM TO BE FILLED OUT BY THE GOVERNMENT OPERATOR AT THE TIME AND AT THE SCENE OF THE ACCIDENT, INSOFAR AS POSSIBLE

DEPARTMENT OR AGENCY: U.S. NAVY

NAME AND LOCATION OF ORGANIZATION TO WHICH YOU ARE ASSIGNED: U.S. NAVAL STATION, WASH. D.C. 20390

I OPERATOR

PLEASE PRINT FULL NAME: GEORGE SMITH

RANK, RATING, OR TITLE: EOCN

SERVICE NUMBER OR ROSTER TITLE: 600-05-24

OPERATOR'S STATE PERMIT NUMBER: 341-56

HOME ADDRESS (Street, city, State): 1015 KEY BLVD., ARLINGTON, VA

TELEPHONE (Home): 926-3777

II TIME AND PLACE

DATE AND DAY OF WEEK OF ACCIDENT: 24 FEBRUARY 19— (TUES)

HOUR (A.M. or [✓ P.M.]): 2:30

PLACE OF ACCIDENT (If accident in city, give city and State; if outside city limits, indicate mileage to nearest city or other landmark.): WASHINGTON, D.C.

FROM WHAT PLACE TO WHAT PLACE WERE YOU BOUND: U.S. NAVAL STATION TO STATE DEPT.

FOR WHAT PURPOSE: GUARD MAIL RUN

III YOUR VEHICLE

MAKE: RAMBLER

TYPE: SEDAN

REGISTRATION NUMBER OR OTHER IDENTIFICATION: 91-00330

PARTS OF VEHICLE DAMAGED (Describe): RIGHT REAR FENDER

ESTIMATED AMOUNT OF DAMAGE $ 85.00

IV OTHER VEHICLE AND PROPERTY (For additional vehicles see page 3)

MAKE: CHEVROLET

TYPE: SEDAN

YEAR: 19—

OPERATOR'S STATE PERMIT NUMBER: 57024

VEHICLE LICENSE NUMBER: MDE 124

OPERATED BY (Name): ALEX POMERANZ

VEHICLE OWNED BY: ALEX POMERANZ

OPERATOR'S HOME ADDRESS (Street, city, State): 6773 WESTERN AVE. WASH. D.C.

OWNER'S ADDRESS (Street, city, State): 6773 WESTERN AVE. WASH. D.C.

PARTS OF VEHICLE DAMAGED (Describe): LEFT FRONT FENDER AND BUMPER DAMAGED AND LEFT HEAD LIGHT BROKEN

ESTIMATED AMOUNT OF DAMAGE $ 220.00

OTHER VEHICLE OR PROPERTY DAMAGED (Describe): NONE

XIII OPERATOR'S STATEMENT OF ACCIDENT AND USE OF SAFETY EQUIPMENT

TELL IN YOUR OWN WAY HOW ACCIDENT HAPPENED

I WAS HEADING SOUTHWEST ON WEEDON AVE. BETWEEN "L" AND "M" STREETS, N.W. AND AS I WAS PROCEEDING ALONG THE AVENUE, THE OTHER VEHICLE PULLED OUT OF A PARKING SPOT. HE HIT MY RIGHT REAR FENDER WITH HIS LEFT FRONT FENDER AND BUMPER.

THE MAN DRIVING THE CHEVROLET SAID THAT HE WAS AT COMPLETE FAULT BECAUSE HE DID NOT LOOK BEFORE PULLING OUT.

WAS VEHICLE EQUIPPED WITH SEAT BELTS? ☑ YES ☐ NO

IF YES, WERE THEY IN USE AT TIME OF ACCIDENT? ☑ YES ☐ NO

SIGNATURE OF OPERATOR: Geo. Smith

DATE: 2-24-

HAVE YOU ANSWERED ALL QUESTIONS AS COMPLETELY AS POSSIBLE?

U.S. GOVERNMENT PRINTING OFFICE : 1963 O—706-356 4

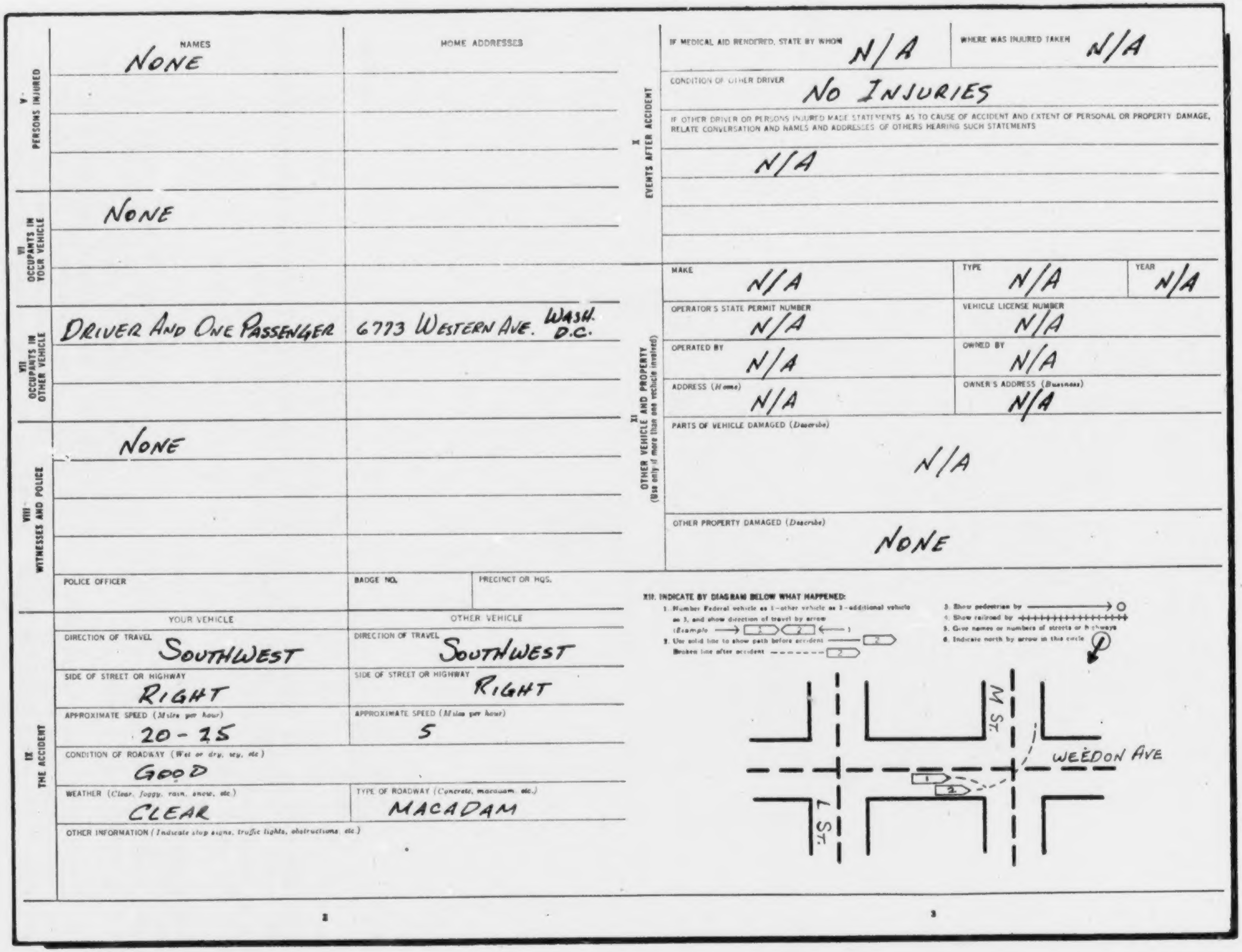
Standard Form 91
Revised April 1963

(91-105)

BUREAU OF THE BUDGET
Circular A-5 (Rev.)

29.52.1

Figure 5-50.—Operator's Report of Motor Vehicle Accident, Standard Form 91, front.



V. PERSONS INJURED

NAMES	HOME ADDRESSES
NONE	

VI. OCCUPANTS IN YOUR VEHICLE

NONE

VII. OCCUPANTS IN OTHER VEHICLE

DRIVER AND ONE PASSENGER 6773 WESTERN AVE. WASH. D.C.

VIII. WITNESSES AND POLICE

NONE

POLICE OFFICER	BADGE NO.	PRECINCT OR HQS.

IX. THE ACCIDENT

YOUR VEHICLE	OTHER VEHICLE
DIRECTION OF TRAVEL SOUTHWEST	DIRECTION OF TRAVEL SOUTHWEST
SIDE OF STREET OR HIGHWAY RIGHT	SIDE OF STREET OR HIGHWAY RIGHT
APPROXIMATE SPEED (*Miles per hour*) 20 - 25	APPROXIMATE SPEED (*Miles per hour*) 5

CONDITION OF ROADWAY (*Wet or dry, icy, etc.*) GOOD

WEATHER (*Clear, foggy, rain, snow, etc.*) CLEAR

TYPE OF ROADWAY (*Concrete, macadam, etc.*) MACADAM

OTHER INFORMATION (*Indicate stop signs, traffic lights, obstructions, etc.*)

X. EVENTS AFTER ACCIDENT

IF MEDICAL AID RENDERED, STATE BY WHOM N/A

WHERE WAS INJURED TAKEN N/A

CONDITION OF OTHER DRIVER NO INJURIES

IF OTHER DRIVER OR PERSONS INJURED MADE STATEMENTS AS TO CAUSE OF ACCIDENT AND EXTENT OF PERSONAL OR PROPERTY DAMAGE, RELATE CONVERSATION AND NAMES AND ADDRESSES OF OTHERS HEARING SUCH STATEMENTS

N/A

XI. OTHER VEHICLE AND PROPERTY (Use only if more than one vehicle involved)

MAKE N/A	TYPE N/A	YEAR N/A
OPERATOR'S STATE PERMIT NUMBER N/A	VEHICLE LICENSE NUMBER N/A	
OPERATED BY N/A	OWNED BY N/A	
ADDRESS (*Home*) N/A	OWNER'S ADDRESS (*Business*) N/A	

PARTS OF VEHICLE DAMAGED (*Describe*) N/A

OTHER PROPERTY DAMAGED (*Describe*) NONE

XII. INDICATE BY DIAGRAM BELOW WHAT HAPPENED:

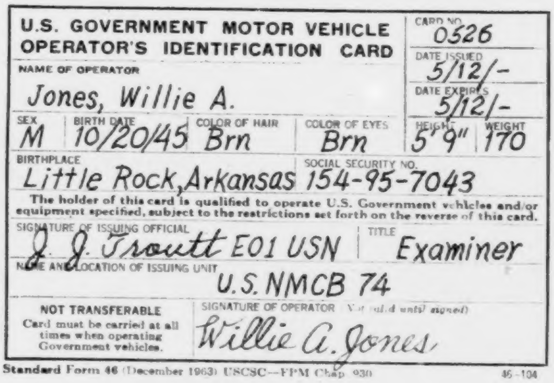
1. Number Federal vehicle as 1—other vehicle as 2—additional vehicle as 3, and show direction of travel by arrow (Example ⟶ 1 2 ⟵)
2. Use solid line to show path before accident ——— 2 Broken line after accident - - - - - 2
3. Show pedestrian by ⟶ ○
4. Show railroad by ┼┼┼┼┼┼┼┼
5. Give names or numbers of streets or highways
6. Indicate north by arrow in this circle

2

3

29.52.2

Figure 5-50.—Operator's Report of Motor Vehicle Accident, Standard Form 91, back.



U.S. GOVERNMENT MOTOR VEHICLE OPERATOR'S IDENTIFICATION CARD

CARD NO. 0526

DATE ISSUED 5/12/-

DATE EXPIRES 5/12/-

NAME OF OPERATOR: Jones, Willie A.

SEX	BIRTH DATE	COLOR OF HAIR	COLOR OF EYES	HEIGHT	WEIGHT
M	10/20/45	Brn	Brn	5'9"	170

BIRTHPLACE: Little Rock, Arkansas

SOCIAL SECURITY NO. 154-95-7043

The holder of this card is qualified to operate U.S. Government vehicles and/or equipment specified, subject to the restrictions set forth on the reverse of this card.

SIGNATURE OF ISSUING OFFICIAL: J. J. Troutt E01 USN

TITLE: Examiner

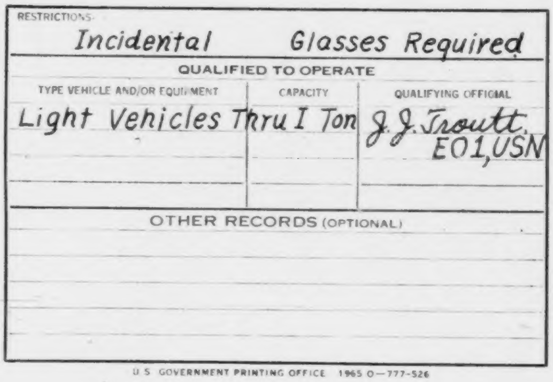
NAME AND LOCATION OF ISSUING UNIT: U.S. NMCB 74

NOT TRANSFERABLE
Card must be carried at all times when operating Government vehicles.

SIGNATURE OF OPERATOR (Not valid until signed): Willie A. Jones

Standard Form 46 (December 1963) USCSC—FPM Chap. 930 46-104

A. FRONT



RESTRICTIONS: Incidental Glasses Required

QUALIFIED TO OPERATE

TYPE VEHICLE AND/OR EQUIPMENT	CAPACITY	QUALIFYING OFFICIAL
Light Vehicles	Thru I Ton	J. J. Troutt, E01, USN

OTHER RECORDS (OPTIONAL)

U.S. GOVERNMENT PRINTING OFFICE 1965 O—777-526

B. BACK

115.238

Figure 5-51.—Accident-Identification Card, DD Form 518.

"claims" an injury when you have no way of knowing the truth. If you cannot get the exact information on some item, write "unknown" to show that you did not overlook it.

If sufficient space is not available for providing information regarding an item, write "see attached sheet," and attach an extra sheet containing the information to the form.

After you have finished your report, look it over carefully and make sure that it is complete and accurate. If you are satisfied that this is so, sign the report, and turn it in to the dispatcher or your supervisor.

Accident-Identification Card

The Accident Identification Card, DD Form 518 (fig. 5-51) is used to provide any person involved in an accident with a Navy vehicle with the name and organizational assignment of the Navy driver. Always fill out DD Form 518 at the scene of the accident, and give a copy to the driver of the other vehicle concerned. If the accident involves a parked car and the owner or operator is not available, place DD Form 518 in or on the parked vehicle. Notify the police immediately, and remain at the scene of the accident until the police arrive or the owner or operator can be located.

CHAPTER 6

MATERIALS-HANDLING EQUIPMENT

The term "materials-handling" describes an activity that constantly goes on in ever project operation—picking up and moving things. It applies to the movement of raw materials, parts in process, finished products, tools, equipment, supplies, and maintenance items. It also applies to both manual and mechanized items. Every operation which involves raising, lowering, or moving an item is materials—handling. Since materials-handling involves lifting, lowering, and moving in some form, lift trucks or rough terrain forklifts excel over other methods of handling.

General information on starting, operating, and maintaining materials-handling equipment is given in this chapter. Also included is information on the capabilities, gross limits, and utilization of materials-handling equipment. In addition, general NCF and signals are described and information is provided on safety precautions to be observed when operating or working near materials-handling equipment.

TYPES OF MATERIALS-HANDLING EQUIPMENT

Materials-handling equipment used by the Navy is especially designed to ensure the performance of necessary tactical materials-handling functions under varied conditions. Military requirements generally limit the use of unmodified commercial types of materials-handling equipment to warehouses or to surfaced outdoor storage areas. Design specifications and performance characteristics of forklifts indicate their capabilities and limitations under adverse conditions. You must recognize these capabilities and limitations to make the most efficient use of the types of materials-handling equipment employed by the Navy.

WAREHOUSE FORKLIFT TRUCKS

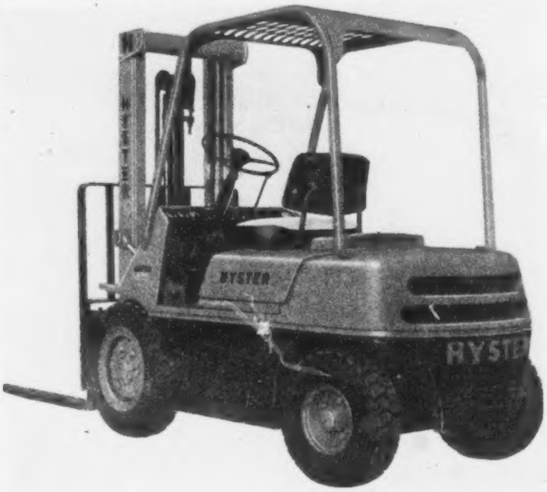
The most common types of warehouse forklift trucks are either electric or gasoline powered with solid, semi-solid, or pneumatic rubber tires. These trucks can be used in warehouses or on surfaced outdoor storage areas. The warehouse forklift truck (fig. 6-1) is a vehicle designed to pick up, carry, and stack unit loads of supplies and equipment. Standard forklift trucks are available with lifting capacities of from 2,000 to 15,000 pounds, and lifting heights from 100 to 210 inches. Forklift trucks are equipped with a telescopic mast that permits loads to be lifted beyond the height of the collapsed mast. They also have a free lift, which is the height to which the forks can be raised before the inner slides move upward from the mast and increase the overall height.

ROUGH TERRAIN FORKLIFT TRUCKS

The rough terrain forklift truck (fig. 6-2) is a self-contained, rider type, mechanized piece of materials-handling equipment, completely equipped to lift loads from 6,000 to 18,000 pounds at a 24-inch load center to a maximum height of 200 inches. The vehicle is designed and equipped for operation on unprepared or unstabilized surfaces, over beaches, in deep sand, or in snow, ice, or mud. It is used primarily for loading and unloading flatbed trailer or landing craft and other types of small cargo vessels.

WHEEL-MOUNTED WAREHOUSE CRANE TRUCKS

A warehouse crane truck (fig. 6-3) is a power-driven, self-propelled unit consisting of a boom mounted on a wheeled chassis. The boom can be operated independently so that slewing and topping can be accomplished without movement of the chassis. With another type of warehouse crane, the chassis must be moved to spot the rigidly mounted boom. Gasoline-powered crane trucks are equipped with pneumatic



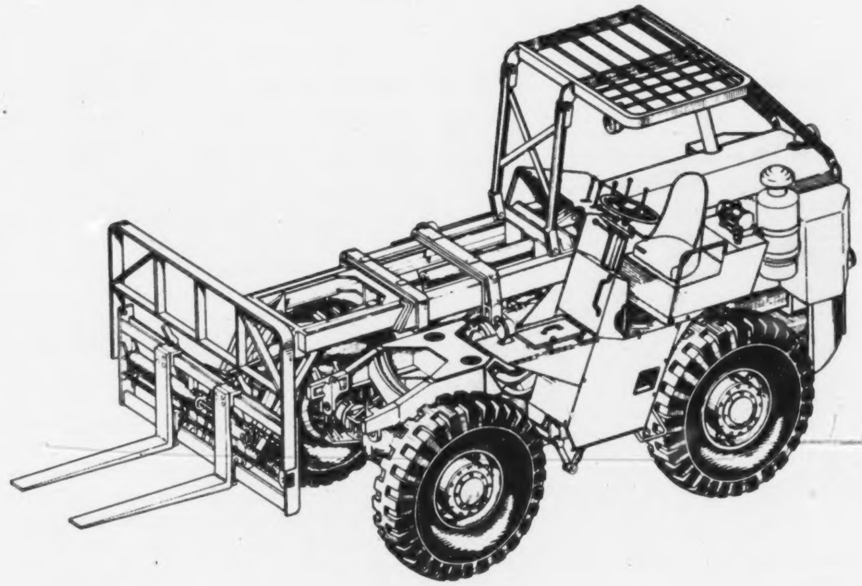
5.58(115G)A
Figure 6-1. — Warehouse forklift truck.

tires for outdoor operation, and range in capacity from 6,000 to 20,000 pounds. Electric-powered crane trucks are equipped with solid rubber tires for indoor operation, and have a capacity of 6,000 to 10,000 pounds.

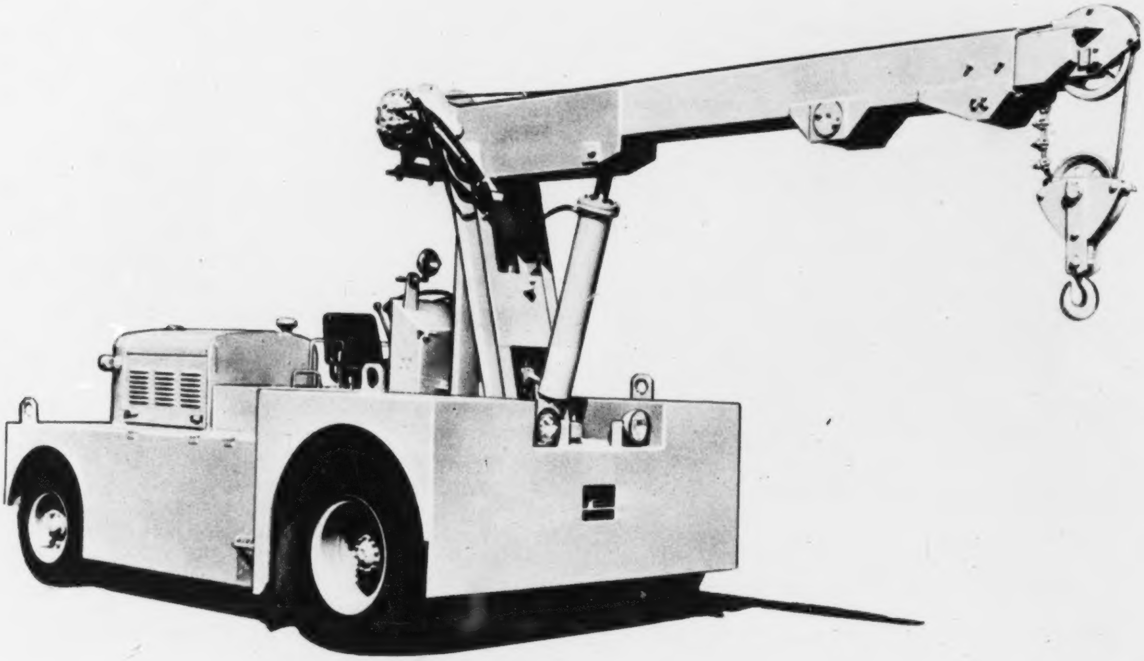
The warehouse crane truck is used to lift, swing, and lower loads that are too heavy, bulky, or otherwise unsuitable for handling by other types of materials-handling equipment. It may be used on piers or docks, as well as in warehouses or freight terminals. It may be used for loading and unloading flatcars or flatbed trailers. The warehouse crane truck is sometimes used to transport loads horizontally for short distances when sufficient overhead clearance is available.

CAPABILITIES, GROSS LIMITS AND UTILIZATION OF MATERIALS-HANDLING EQUIPMENT

In the selection of a forklift truck, consideration should be given to the performance, lift height, type of power, and capacity required (see table 6-1), as well as the available space in which the forklift will operate.



5.58(115G)B
Figure 6-2. — Rough terrain forklift truck.



115.435

Figure 6-3. — Wheel-mounted warehouse crane truck.

Forklift trucks are available in standard models, with lift heights up to 210 inches. These trucks have telescopic masts which permit lifts beyond the height of the collapsed mast height. Free lift permits the placement of a second tier of pallets on top of the first tier in a building with a low ceiling or in congested areas.

The lift height of a forklift truck selected for a project will depend upon the (1) height of storage, (2) overall height of the forklift truck with mast lowered; which must clear door casings, (3) overhead obstructions, and (4) other building limitations. In addition, there are other restrictions during unloading and loading of cargo vessels, trucks, trailers, and so forth.

Materials-handling equipment may either be electric-, gasoline, or diesel-powered.

The forklift truck pivots on the center of the drive axle. Therefore, the weight of the load ahead of the front wheels must be counterbalanced by the weight of the truck, including any additional counterweight added by the manufacturer. In accordance with the principles of leverage, the ability of the forklift truck to lift a load depends upon the length of the load and the weight of the load. In addition to the rated load weight, the capacity of the forklift truck can also be measured in inch-pounds, by multiplying the distance from the center of the front axle (in inches) to the center of the rated load (in pounds).

To determine the inch-pounds capacity of a forklift truck, add to load center, the distance from the center of the front axle to the heel of the forks, which can be obtained from the manufacturer's specifications or by measurement, and multiply the sum by the rated load weight. For example: Assume a rating of 4,000 pounds at 24 inches, with a measurement of 15 inches from the center of the front axle to the heel of the forks. Result: 4,000 pounds x (24 + 15) = 156,000 inch pounds.

Table 6-1. — Materials-Handling Equipment Capacities

WAREHOUSE FORKLIFT TRUCKS

LOAD CAPACITY IN POUNDS	LIFT HEIGHT CAPACITY IN INCHES	COLLAPSED MAST HEIGHT IN INCHES	FORK LENGTH IN INCHES
Solid or Semisolid Rubber-Tired			
2,000	100	68	36
2,000	127	83	36
4,000	100	68	40
4,000	144	91	40
6,000	100	68	40
6,000	127	83	40
6,000	168	113	40
Pneumatic Rubber-Tired			
2,000	127	83	36 or 40
4,000	144	91	40
6,000	127	83	40
6,000	168	115	40
15,000	210	153	48

ROUGH TERRAIN FORKLIFT TRUCKS

4,000	144	96	48
6,000	144	96	48
10,000	144	96	54 to 60
10,000	144	96	54 to 60
18,000	212	172	48 to 96

WHEEL-MOUNTED WAREHOUSE CRANE TRUCKS

LOAD CAPACITY IN POUNDS	HOOK REACH IN INCHES	BOOM SLEWING
4,000	60	180
6,000	36	180
6,000	60	180
10,000	36	180
10,000	60	180
20,000	36	180

115.436

To determine the maximum weight which may be placed on a pallet of a given size, add half the dimension of the pallet parallel to the forks to the distance from the center of the front axle to the heel of the forks, and divide the sum into the inch-pound capacity of the forklift truck. To complete the example, the maximum weight on a 40- by 48-inch pallet is 156,000 inch-pounds divided by (15 + 20), which equals approximately 4,460 pounds. However, the load weight may not be in excess of the weight of the rated load stated by the manufacturer. If the dimension of the pallet used, parallel to the forks, is less than twice the rated load center, the rated pounds capacity is the capacity of the forklift truck. Therefore, the maximum load would still be 4,000 pounds.

It is important that the capacity of the equipment be equal to the task. For this reason, the weight of each load must be ascertained before a lift is made.

Usually, the lifting and carrying capacity of the warehouse crane truck is stated as the maximum weight which may be lifted at various boom angles. If the boom is telescopic, maximum capacity is obtained with the boom at the shortest length. As the boom is lowered toward the horizontal position, or as its length is extended, capacity decreases. If the crane truck must ravel over rough or uneven ground, the capacity is further reduced. Under all circumstances, a load chart showing its capacity should be visible on the crane truck. These charts, furnished by the manufacturer, will indicate clearly the safe load in pounds for maximum and minimum position of the boom and for at least two intermediate stations. The operator must be aware of the factors which influence the capacity of the crane truck and must understand that the crane truck will not lift the maximum capacity under all circumstances.

PRINCIPLES OF OPERATION OF WAREHOUSE FORKLIFT TRUCKS

A forklift truck operates on the simple principle of a fulcrum or teeter-totter. A unit load on the forks must be counterbalanced by the counterweight and truck weight. The fulcrum or pivot is the drive axle. However, a forklift truck is more complex than just a load, fulcrum, and counterweight. It must be physically small and compact in order to work in confined areas such as boxcars and narrow aisles. Yet, it must offer adequate working space for both operator and maintenance man. It must be able to handle maximum loads and stack them safely and still have an upright with a minimum load collapsed height which will enable it to maneuver in areas with low overhead clearance. It must be able to negotiate inclines, either empty or loaded.

PRINCIPLES OF OPERATION OF ROUGH TERRAIN FORKLIFT TRUCKS

The primary function of a rough terrain forklift truck is for the rough terrain handling of materials. The rough terrain forklift truck is a self-contained, rider type, mechanized piece of materials-handling equipment and is capable of lifting and transporting loads up to 18,000 pounds. The rough terrain forklift truck may also be used as a prime-mover for towed equipment.

The hydraulic-operated forklift mechanism mounted on the extreme front of the rough terrain forklift truck provides the means for lifting, reaching, tilting, and sliding loads during materials-handling operations.

Provision is made on the rough-terrain forklift truck for rotating the truck frame about its longitudinal axis when operating over rough terrain. This action is accomplished by means of manipulation, by the operator, of the control which activates the oscillating cylinder. The rough terrain forklift truck is also equipped with a torque-converter-type transmission, which provides smooth acceleration and deceleration and ease of handling.

PRINCIPLES OF OPERATION OF WAREHOUSE CRANE TRUCKS

The hydraulically operated boom crane mechanism mounted on the front of the warehouse crane truck provides the means for lifting, swinging, and lowering loads that are too heavy, bulky, or otherwise unsuitable for handling by other types of materials-handling equipment.

The action of the hydraulically operated control levers provides the means for load lifting, slewing (turntable rotation), winching (cable control), and boom crowding (extending) during materials-handling operations.

The warehouse crane trucks drive system is equipped with a torque converter; a four-speed, forward and reverse power shift transmission; a differential; and a drive axle.

OPERATION OF MATERIALS-HANDLING EQUIPMENT

The sole source of complete and authentic information on materials-handling equipment operations is the operator's manual provided by the manufacturer of the materials-handling equipment concerned.

The information given in this section describes the prestart checks, starting and operating procedures, during operations checks, and securing methods which are typical of materials-handling equipment used by the Navy.

PRESTART CHECK

Prestart check and service made on materials-handling equipment are consistent with the principles described for automotive vehicles in the preceding chapter. However, the location of items to be checked differs from one type of materials-handling equipment to another.

Assume for purposes of this discussion that you are to make a prestart check of a WAREHOUSE FORKLIFT TRUCK, of the type shown in figure 6-1.

First check the lubricating oil, radiator coolant, fan belt, battery, fuel, and hydraulic oil. Tilt up the counter-balanced hood for access to these items.

Making sure the forklift hoist is lowered to the ground, check the hydraulic oil lever with the bayonet gage provided. The level should be between the upper (full) and lower marks on on the gage. If it is not, add a sufficient amount of the specified type of hydraulic oil to raise the level as recommended. CAUTION: Never operate the engine without oil in the hydraulic system. A few revolutions without oil can ruin the hydraulic pump.

When checking the wheels, tires, lights, and horn on the warehouse forklift truck, follow the same procedures as described for automotive vehicles in the preceding chapter.

In making a prestart check of the ROUGH TERRAIN FORKLIFT TRUCK (fig. 6-2), lift the engine side panels, thus allowing access for checking the lubricating oil and fan belt(s).

Check the water level in the radiator. The radiator is located at the rear of the vehicle. Next, check the supply of fuel in the fuel tank. This tank is located on the right side of the vehicle beside the operator's compartment. Check the level of the hydraulic oil in the reservoir. If necessary, add the specified type of hydraulic oil to bring the level up to the "FULL" mark on the dipstick. This reservoir is located under the operator's compartment.

Be sure to secure the drain cocks on the air reservoir tanks as you continue your prestart check. One air reservoir tank is mounted horizontally and adjacent to the power cluster assembly located above the bell housing, and another tank is mounted vertically and to the right of the operator's compartment.

Check the water level of the batteries. You will find two 12-volt negative-grounded batteries connected in series; they are mounted one on each side at the rear of the vehicle.

When checking the wheels, tires, lights, and horn, on the rough terrain forklift truck, follow the same procedures as described for automotive vehicles in the preceding chapter.

Another piece of materials-handling equipment on which you would make a prestart check is the WHEEL-MOUNTED WAREHOUSE CRANE TRUCK (fig. 6-3.)

In making this prestart check, lift the engine compartment side panels enabling you to check the lubricating oil level and fan belt(s).

Check the water level in the radiator. The radiator is located at the rear of the vehicle.

Now check the hydraulic oil reservoir which is located on the right side of the vehicle. The level of the hydraulic oil must be maintained to the top of the filler tube with the specified type of hydraulic oil.

As you continue, check the water level of the batteries. You will find two 12-volt, negative-grounded batteries connected in series, mounted in a battery box to the right of the operator's seat.

Check the winch drum and cable located at the rear of the boom assembly for wear and defective windings. When necessary, replace with the recommended type, length, and size cable prescribed by the manufacturer.

When checking the wheels, tires, lights, and horn on the wheel-mounted warehouse crane truck, follow the same procedures described for automotive vehicles in the preceding chapter.

STARTING CHECKS

After starting the engine, but before putting materials-handling equipment into operation, a few additional checks are necessary. Major items to be covered in a starting check of the WAREHOUSE FORKLIFT TRUCK, the ROUGH TERRAIN FORKLIFT TRUCK, and the WAREHOUSE CRANE TRUCK are given below.

Warehouse Forklift Truck

Your forklift may be equipped with either a generator or an alternator. Their operation is checked by either an ammeter gage or a red warning light marked GEN. The ammeter may show a slight discharge at engine idle, but should indicate charging in a positive direction when the engine speed is increased. When the GEN light is on, the generator is not charging. This light may be on at engine idle, but should go out with increased engine speed.

Engine oil pressure is indicated by either a pressure gage or an engine oil warning light. The gage may register high pressure when the engine is first started in cold weather, but the pressure should drop to its normal level of 20-30 psi as the engine warms up. The warning light will go on when the oil pressure is too low for safe operation. If the warning light goes on or the gage indicates no pressure, stop the engine and notify the maintenance shop.

You should also check the engine coolant temperature gage, which should move upward as the engine warms up to a normal 182°F.

Rough Terrain Forklift Truck

Your rough terrain forklift's engine oil pressure gage should indicate pressure within 30 seconds after the engine starts. The indicated pressure should not fall below 30 psi at operating speed and normal pressure should be higher. If there is no indication of pressure within the 30 seconds, or if the pressure is low, contact the maintenance shop.

The battery-generator indicator (ammeter) on the rough terrain forklift should indicate a positive charge reading immediately upon starting the engine with the lights and accessories turned off.

Check the engine coolant temperature gage after the engine is operating normally. The gage should register between 160° and 185°F.

As you check your instruments further, the air pressure light should remain off when the air pressure gage is registering at normal pressure of 90 to 100 psi. When the air pressure falls below 60 psi, the low air pressure light should come on, indicating there is low air pressure in the system. If the light does not go out and the air pressure gage does not register in the proper operating range, stop the engine and notify the maintenance shop.

Check the converter pressure gage which indicates the fluid pressure in the torque converter. You should also check the converter temperature gage which indicates the oil temperature in the torque converter in degrees Fahrenheit.

Warehouse Truck Crane

Check the engine oil pressure gage. At normal operating temperature and governed speed, the gage should show a pressure between 25 and 35 psi. If the gage fails to show a proper pressure reading, stop the engine and notify the maintenance shop.

The engine temperature gage indicates engine coolant temperature by a dial reading from 100° to 240°F. Under normal conditions, the gage should register a temperature of approximately 180°F.

Check the transmission oil pressure gage which indicates the oil pressure within the transmission. You should also check the transmission temperature gage, which indicates the temperature of oil circulating in the transmission.

DURING OPERATION CHECKS

When a piece of materials-handling equipment is not operating properly, there are various symptoms by which the malfunction usually can be identified. You should be able to recognize those symptoms, and stop the machine before damage results. These symptoms have been covered in chapter 5 of this manual. Therefore, these symptoms need not be repeated here.

OPERATING WAREHOUSE FORKLIFT TRUCKS

The safe and efficient use of a warehouse forklift truck requires skill and alertness on the part of the operator. For the majority of materials-handling operations the forklift truck excels over other methods because it is self-propelled and requires only the operator to control its lifting, transporting, stacking, and unstacking operations. To develop the skill required for safe and efficient forklift truck operation, you should become familiar with the makeup of your forklift truck, understand its capabilities and limitations, and see that it is maintained in good mechanical condition.

Let's take a look at one particular model of warehouse forklift truck to familiarize you with the instruments and controls, as well as operation capabilities. The information given is on the Hyster "Monotrol" model, and applies only to that machine.

The Monotrol forklift instrument panel and controls are shown in figure 6-4. The instrument panel is equipped with an ammeter, coolant temperature gage, fuel gage, oil pressure indicator, oil temperature indicator, manual choke, and key ignition and starter switch.

The major controls of the forklift that you should be familiar with, and their function, are

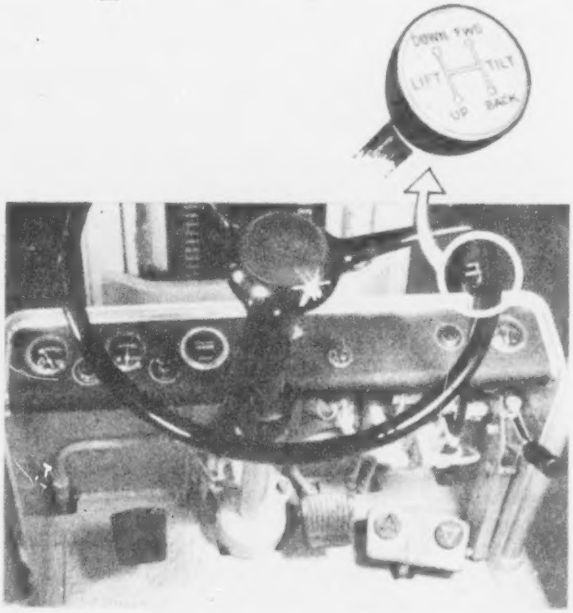


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Figure 6-4. — Warehouse forklift truck instruments and controls (Hyster "Monotrol" model).

explained below. An inching pedal, sometimes referred to as the left brake pedal, is located on the left side of the steering column. By adjusting the pedal position with your left foot, you can control the forklift truck movement in small increments (inching) at high engine speed. Complete application of this pedal places the transmission in neutral and sets the service brakes.

The brake pedal is located to the right of the steering column and is operated by your right foot. This brake pedal is independent of the inching pedal and has no connection with the transmission. The brake pedal is used for braking only — and not for inching.

The Monotrol pedal is located to the right of the brake pedal. The forklift truck's direction and speed are controlled by your foot on the Monotrol pedal. The pedal surface has two circular pressure pads, one on each side. The pads are marked for the direction of travel as shown in figure 6-4. Pressure on either pad actuates the powershift transmission in the direction selected. Additional pressure on either pad accelerates the engine in the same manner as a conventional throttle.

The parking brake is an over-center type lever located next to the Monotrol pedal. When you pull the brake lever up to the applied position, the transmission shifts to neutral, the parking brake applies, and the starter circuit closes. The engine may be left running or turned off, but the engine can only be started with the parking brake applied. Releasing the brake lever places the transmission in gear, releases the parking brake, and opens the starter circuit. To move in the desired direction, merely step on the corresponding side of the Monotrol pedal.

The Monotrol pedal should not be used as a service brake by changing direction when the truck is moving.

When starting the Monotrol forklift truck, set the parking brake which completes the starter circuit and allows the starter to engage. Next, turn the key ignition switch until the starter engages. Allow the engine to turn over until it starts. Then, release the key and it will return automatically to "run" position. It should not be necessary to crank the engine for a prolonged period of time. If it does not start within a reasonable time, something is wrong. Find out what it is and have it corrected. When the engine is cold, it may be necessary to choke it for a second or two. If the engine is hot, choking should not be necessary, but depress the accelerator about halfway to facilitate starting.

The hoist and tilt mechanisms are both actuated by the same lever (see fig. 6-4.) When you pull the lever back, the hoist will lift. When you push the lever forward, the hoist will lower. To tilt the uprights back, push the lever to the extreme right and then pull it back. Now push the lever forward and the uprights will tilt forward. When the control lever is released, it will automatically return to neutral and stop either the hoist or tilt operation.

Lifting speed is controlled by (1) the speed of the engine, and (2) the extent the control lever is pulled. Engine speed has no effect on lowering speed.

When loading and stacking material, move the forklift truck forward until the load arms are entirely under the load to be lifted. Make certain that the load is centered on the arms and that it is well seated against the face of the lifting carriage. When picking up round objects, first tilt the uprights so that the forks slide along the floor or ground under the object to be lifted as shown in figure 6-5. Depress the inching pedal, which disengages the transmission and sets the service brakes, and accelerate the engine with the Monotrol pedal. When sufficient backward tilt of the uprights is obtained to allow safe handling of the load, move the hydraulic lever back to neutral and then move it to the left position and pull back. At the same time, accelerate the engine until the desired hoist speed is obtained.

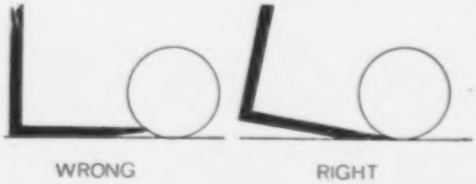

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Figure 6-5. — Using tilt properly to pick up round objects.

Never race the engine while hoisting a load. Engine speeds above 2,200 rpm will not increase speed of the hoisting mechanism and will only result in excessive wear and damage to the engine. With a little practice, you will learn by sound, observation and "feel" the maximum efficient hoisting speed. When the load has been raised to the desired height, ease the hoist lever to the neutral position and move the forklift truck to the base of the stack on which the load is to be placed.

Although the load may be placed on or removed from a stack by using the hoist lever, you will discover that with practice the loads can be placed or removed entirely with the tilting mechanism. The tilting mechanism is designed to raise the load arms slightly as the uprights are tilted backwards.

Practice raising the load as the forklift truck is nearing the stack while coasting into position. This reduces strain on the engine and the brakes. You are urged to study the problem of load handling, keeping in mind that carefully planned operations will produce the maximum amount of work with minimum fatigue to yourself.

When transporting a load, tilt the uprights as far back as the nature of the load will permit and raise the load only high enough (4 to 6 inches) to clear obstructions. Always reduce speed gradually as sudden stops will cause excessive brake wear and will cause the load to fall forward.

Know the underclearance of your forklift truck, and the surface upon which you are traveling at all times.

When operating a forklift truck on a steep incline, back down with the load, and drive forward when climbing a steep incline.

OPERATING ROUGH TERRAIN FORKLIFT TRUCKS

Let's take a look at one particular model of rough-terrain forklift truck to familiarize you with the instruments and controls, as well as operating capabilities. The information given is on the Pettibone-Mulliken, Model OS-3354, and applies only to that machine.

The purpose of the various instruments on the forklift is explained below: letters in parentheses correspond to those used in figure 6-6 to indicate the location of the instruments.

The LOW AIR PRESSURE LIGHT (A), when lit indicates low air pressure (below 60 lbs) in the compressed air system.

The THROTTLE CONTROL (D) is a hand-operated control for adjusting engine speed during warm-up periods and when operating the forklift mechanism while at a standstill. Engine speed increases in direct proportion to the amount of throttle control that is pulled out.

The CONVERTER PRESSURE GAGE (E) is electrically connected to the torque converter pressure sending unit. The gage indicates fluid pressure in the torque converter.

The ENGINE OIL PRESSURE GAGE (F) is connected electrically to the oil pressure sending unit and gives an indication of the engine oil pressure in pounds-per-square-inch.

The STARTER BUTTON (G), when depressed, supplies electrical power from the batteries to activate the starter motor.

The BATTERY-GENERATOR INDICATOR (H) is electrically connected to the batteries and generator. The indicator operates when the ignition switch is placed in the ON position.

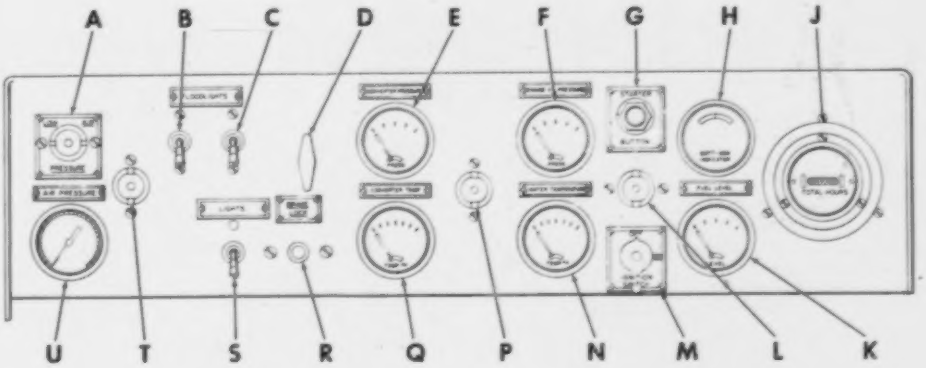
The ENGINE HOUR METER (J) indicates the total hours of operation of the engine assembly in tenths of an hour to the maximum of hours.

The IGNITION SWITCH (M), when turned to the ON position, supplies electrical power to the instrument panel and starting controls. Always turn the switch to OFF position when stopping the engine.

The WATER TEMPERATURE GAGE (N) is connected electrically to the water temperature sending unit mounted in the water manifold. The gage indicates the engine coolant temperature in degrees Fahrenheit.

The CONVERTER TEMPERATURE GAGE (Q) is connected electrically to the torque converter temperature sending unit and indicates the oil temperature in the torque converter in degrees Fahrenheit.

The BRAKE LOCK PUSH-BUTTON SWITCH (R) is connected electrically to the brake lock mounted in series with the rear brake fluid line. The mechanism is used as a supplementary



A	Low air pressure light	K	Fuel level gage
B	Forward floodlight switch	L	Panel light
C	Rear floodlight switch	M	Ignition switch
D	Throttle control	N	Water temperature gage
E	Converter pressure gage	P	Panel light
F	Engine oil pressure gage	Q	Converter temperature gage
G	Starter button	R	Brake lock push-button switch
H	Batt-generator indicator	S	Service lights switch
J	Engine hour meter	T	Panel light
U	Air pressure gage		

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Figure 6-6.—Instrument panel arrangement, rough terrain forklift (Pettibone-Mulliken model OS-3354).

braking system for steep grades. To apply the brake lock, step on the brake pedal to the desired braking action required. While holding the brake pedal, press the BRAKE LOCK push-button switch. The switch activates the brake lock which traps the pressurized hydraulic brake fluid at the rear wheel lines, thus keeping the brakes engaged after the driver removes pressure from the brake pedal. To release brakes, push the brake pedal in to at least the same pressure as applied when activating the brake lock.

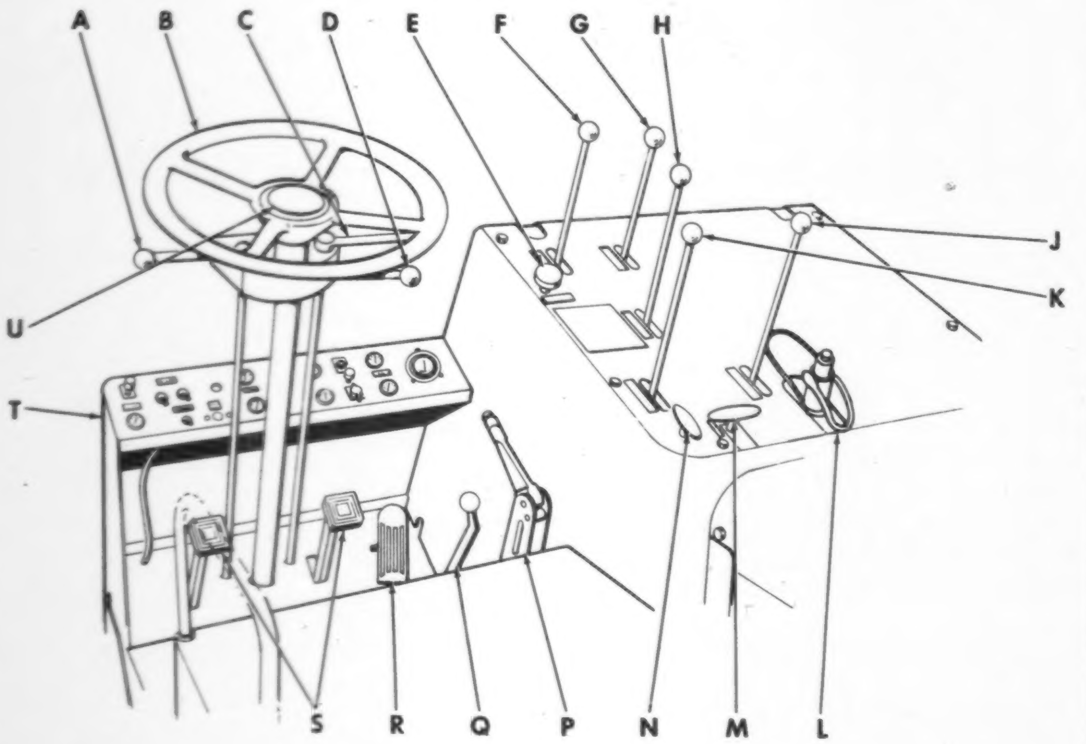
NOTE: Do not touch brake lock switch when removing brake lock action.

The AIR PRESSURE GAGE (U) is tube connected directly to the vertical air reservoir tank. The gage gives and indicates the amount of pressure in the reservoir in pounds-per-square-inch.

The purpose of the controls is explained below; the letters in parentheses correspond to those used in figure 6-7 to indicate the location of the controls.

The STEERING SELECTOR LEVER (A) consists of a knob-type lever, and mechanical linkage which is attached to the four-way selector valve. The steering selector enables the operator to steer the vehicle with the two front wheels or all four wheels. Two conditions can be selected in the four wheel steering range: crabbing and fourwheel.

When the steering selector lever is pushed upward to CRAB position, the vehicle will operate in crab position (the vehicle will move slightly sideways). When the steering selector lever is pulled downward to FOURWHEEL, the vehicle will be in the fourwheel position (the two rear wheels turning in the opposite direction



A	Steering selector
B	Steering wheel
C	Speed selector
D	Direction selector
E	Disconnect drive control
F	Fork lift control
G	Fork tilt control
H	Fork reach control
J	Fork rotation (oscillation) control
K	Fork side-shift control
L	Cold start control
M	Emergency stop control
N	Engine off control
P	Emergency brake lever
Q	Drive selector
R	Accelerator pedal
S	Service brake pedals
T	Instrument panel
U	Horn button

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Figure 6-7. — Controls, rough terrain forklift (Pettibone-Mulliken model OS-3354).

from the front wheels causing the vehicle to pivot or make a sharp turn). When the steering selector is moved to the midposition, FRONT WHEEL, the vehicle will be in the front wheel steering position (the vehicle will make a normal right or left turn.

NOTE: All wheels must be in the straight ahead position before changing the steering selector from either crab or fourwheel position. Failure to observe this will result in erratic vehicle movement plus tire damage.

The SPEED SELECTOR (C) consists of a knob type lever and mechanical linkage which is attached to the transmission assembly speed selector valve. The control shifts the transmission into either the low, medium, or high driving range. The various gear ranges are chosen by the operator to move the vehicle over varying types of terrain.

When the speed selector control is pushed upward to LO the vehicle transmission is in the low driving range. When the speed selector is pulled down to HI, the transmission is in the high driving range. By placing the speed selector control in the center position (MED), the transmission is in the medium range. Normally the operator will shift from low to medium, to high range, as the severity of the terrain decreases.

The DIRECTION SELECTOR (D) consists of a knob type lever and mechanical linkage connected to the transmission assembly direction valve. The control shifts the transmission valve to the forward, reverse, or neutral position.

When the direction selector is pushed upward to FWD, the transmission will be in the forward operating position. When the direction selector is pulled all the way down to REV, the transmission is in the reverse operating position. Moving the direction selector to the center on NEUTRAL position places the transmission in neutral position.

The DISCONNECT DRIVE CONTROL (E) is manually operated, and when engaged allows the operator to speed up the engine, thus increasing the hydraulic pump capacity without moving the vehicle. To operate, pull the control out and apply the brakes. To disengage, press the control in. When the control is out, the transmission valve is engaged and tied in with the brake system to enable the operator to "inch" the vehicle.

When the FORKLIFT CONTROL (F) is pushed toward the front of the vehicle (LOWER), the entire carriage and fork assembly will be lowered. When the FORKLIFT CONTROL is pulled toward the rear of the vehicle (RAISE), the entire carriage and fork assembly will be raised. The center position is a stop for any previously selected position.

When the FORK TILT CONTROL (G) is pushed toward the front of the vehicle (FORWARD), the entire carriage and fork assembly is tilted forward. When the fork tilt control is pulled toward the rear of the vehicle (REARWARD), the entire carriage and fork assembly is tilted rearward. The center position is a stop for any previously selected movement.

When the FORK REACH CONTROL (H) is pushed toward the front of the vehicle (EXTENDED), the entire carriage and fork assembly is extended forward. When the fork reach control is pulled toward the rear of the vehicle (RETRACT), the entire carriage and fork assembly will be retracted. The center position is a stop for any previously selected movement.

When the FORK ROTATION CONTROL (J) is pushed toward the front of the vehicle (RIGHT); the vehicle will tilt (dip) 10° to the right. When the lever is pulled toward the rear of the vehicle (LEFT), the vehicle will tilt (dip) 10° to the left. The center position is a stop for any previously selected movement.

When the FORK SIDE-SHIFT CONTROL (K) is pushed toward the front of the vehicle (RIGHT), the forks will move to the right of the driver. When the fork side-shift control is pulled toward the rear of the vehicle (LEFT), the forks will move to the left of the driver. The center position is a stop for any previously selected movement.

The EMERGENCY STOP CONTROL (M) enables the operator to stop the engine in the event an abnormal condition arises. The control will prevent damage to the engine by cutting off the air supply and thus stopping the engine. Push the lever in and the engine is ready for operation again. On other models, the operator must leave the operator's seat and reset the emergency stop control on the engine.

CAUTION: The emergency stop control should never be used to stop the engine except in an emergency. If the control is frequently used, this can cause oil to be sucked past the oil seals and into the blower housing.

The ENGINE OFF CONTROL (N) enables the operator to stop the engine. Pulling the control out stops the vehicle fuel supply at the engine governor assembly.

When the DRIVE SELECTOR (Q) is pushed forward (toward the front of the vehicle), all four wheels become powered drive wheels. When the drive selector is pulled back (toward the driver), only the two rear wheels are powered.

The ACCELERATOR PEDAL (R) is operated by the driver's right foot and controls the vehicle engine speed. The engine operates at the maximum governed speed when the accelerator pedal is fully depressed. When the pedal is released, the engine operates at the predetermined idle speed.

Since nearly every job presents a different problem, the operator may have to vary given procedures to fit the individual job. When starting, make sure the torque converter transmission direction selector is placed in the NEUTRAL position. Place all carriage and fork assembly levers in the central position. Be certain the parking brake is engaged, and the ENGINE OFF CONTROL is all the way in to hold the valve open. Pull the throttle control out to its halfway position and lock by turning the "T" handle clockwise. Turn the ignition switch to the ON position; press the starter button until the engine starts.

NOTE: Never press the starter button any longer than 30-seconds. If the engine fails to start within this time, allow the starting motor to cool for 15 seconds before attempting to start the engine again.

After the engine has started, check your instruments. The engine oil pressure gage should indicate pressure within 30 seconds after the engine has started. The indicated pressure should not fall below 30 psi at normal operating speed. In addition, the battery-generator indicator should indicate a charge reading immediately after starting with lights and accessories turned off.

The engine should be operated through a short warm-up period prior to putting the vehicle to work. This enables the operator to observe the other instruments and check the engine operation. Another important gage for the operator to observe is the engine coolant temperature gage which should show a temperature within a range of 160° and 185°F when the vehicle is operating under normal conditions.

After the engine is operating normally, the following procedures must be followed for normal vehicle operation:

Be certain all wheels are in a straight ahead position and move the steering selector lever to the FRONT WHEEL position. When operating on level, smooth terrain, place the drive selector lever back (toward the operator) allowing for two wheel drive (rear wheels) operation. Move the direction selector lever to FWD (forward) position, and then move the speed selector control to MED (medium) or HI (high) range position. The desired road speed can be obtained by simply depressing the accelerator pedal.

NOTE: With the engine at slow idling speed and the vehicle on smooth level ground, the torque converter transmission will exert sufficient torque to take up any slack or play in the drive line, and possibly cause the vehicle to "creep" slowly forward.

Under normal terrain operating conditions, HI range is used when operating the rough terrain forklift truck. LO range is very seldom required under normal operating conditions, even with a full rated load or on ordinary grades. LO range is usually used for ascending steep grades in very rough terrain, or in mud, sand or snow. LO range is always used when descending long, steep grades where more or less continuous braking would otherwise be required.

To stop the rough terrain forklift truck, release pressure on the accelerator pedal and depress the brake pedal. Do not pump the brake pedals, but apply an even pressure. This will permit the drive train to assist in braking the vehicle.

If the stop is momentary and direction of travel is not to be reversed, the direction selector need not be shifted to neutral. The vehicle can be held stationary by a light brake pedal pressure. Forward motion can be resumed simply by releasing brake pedal pressure and depressing the accelerator. However, if the vehicle is to be stopped and remain stationary, place the direction selection lever in neutral and apply the parking brake.

When reversing the vehicle, the vehicle must be brought to a complete stop before moving the direction selector to the REV (reverse) position from the FWD (forward) position. The engine should always be at a slow idle speed when shifting. When shifting to the REV position from neutral, the direction selector shift lever should always be moved to the FWD position first and then shifted without pause through neutral to REV position. When shifting from REV to FWD the direction selector shift lever should be left in neutral position for at least 3 seconds before shifting into FWD position.

It is possible for the operator to inch the vehicle into position through proper operation of the brake pedals. To inch the vehicle forward, the operator pulls the DISCONNECT DRIVE CONTROL (E, fig. 6-7) to the out position and applies slight pressure to either or both brakes. This allows the operator to speed-up the engine for maximum lifting power while inching the vehicle into position with the load. It is only necessary for the operator to depress the brake pedals an additional amount to stop inching and apply the brakes.

Some additional operating precautions to observe when operating the rough terrain forklift truck are as follows:

1. When ascending steep grades, shift the speed selector lever to LO range.
2. When descending steep grades, the speed selector lever must be in LO range.
3. Allow the engine with its governor to act as a brake and prevent the vehicle from attaining excessive speeds when rolling downgrade.
4. Remember, excessive speeds will impose severe strain on the entire drive line; use proper operating techniques.
5. The vehicle, when operating under its own power, must never be allowed to coast downhill with speed selector in NEUTRAL. The speed selector must be in gear at all times when the vehicle is traveling under its own power.
6. The vehicle is designed to operate in water, up to a depth of 5 feet. Before operating the vehicle in water, it is necessary to loosen the fan belts. After fording, remember to tighten the fan belts; otherwise overheating of the engine may occur.

OPERATING WHEEL-MOUNTED WAREHOUSE CRANE TRUCK

Let's take a look at one particular model of the wheel-mounted warehouse crane truck to give you an idea of the instruments and controls, as well as operating capabilities. The information given is on the Pettibone-Mulliken, Model 10F, and applies only to that machine.

The purpose of the various instruments on the warehouse crane truck is explained below.

The numbers in parentheses correspond to those used in figure 6-8 to indicate the location of the instruments.

The HOUR METER (1) indicates the total number of hours the engine has been in operation in tenths of an hour to the maximum hours.

The AMMETER (2) indicates the amount of current being put into or withdrawn from the battery. The dial reads from -30 amperes to +30 amperes. When the engine is running at full governed speed and the battery is fully charged, the dial needle should move slightly to the positive side of the 0 mark on the dial. When the needle indicates a constant discharge, stop the engine and have a mechanic check out the malfunction.

The ENGINE OIL PRESSURE GAGE (4) indicates pressure of the oil in the engine lubricating system on a dial reading from 0 to 80 psi. At normal operating temperature and governed speed, the gage should show a pressure reading between 25 to 35 psi. If the gage fails to show a reading in this range, stop the engine and have the cause of the malfunction checked out.

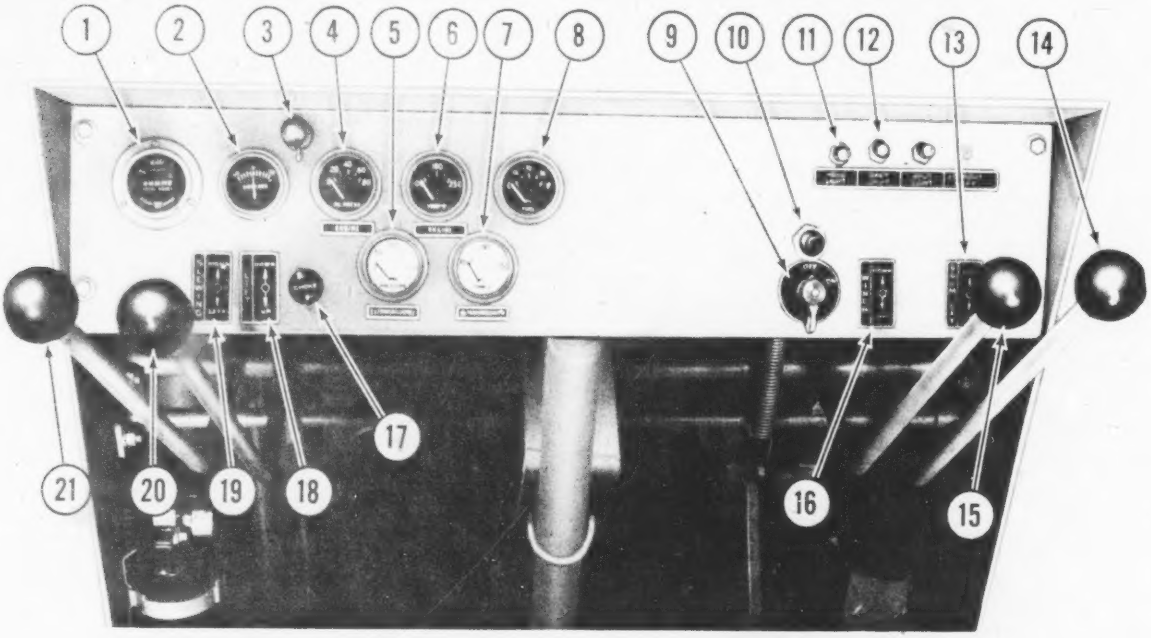
The ENGINE TEMPERATURE GAGE (6) indicates the temperature of the engine cooling fluid on a dial reading from 100° to 240°F. Under normal operating conditions, this temperature should be approximately 180°F.

The FUEL GAGE (8) indicates the amount of fuel in the tank. The dial reads from empty to full in one-quarter increments.

The CHOKE (17) is used to enrich air-fuel mixture. The normal operating position is for the choke control to be pushed in toward the front hood support as far as it will go. To enrich the air-fuel mixture when starting a cold engine, pull the choke control out. Push the choke control in, as the engine warms up.

The OIL PRESSURE GAGE (TRANSMISSION) (5) indicates the pressure of oil in the transmission on a gage reading from 0 to 200 lbs.

The TEMPERATURE GAGE (TRANSMISSION) (7) indicates the temperature of oil circulating



LEGEND:

1. HOUR METER
2. AMMETER
3. DASH LIGHT SWITCH
4. ENGINE OIL PRESSURE GAUGE
5. TRANSMISSION OIL PRESSURE GAUGE
6. ENGINE TEMPERATURE GAUGE
7. TRANSMISSION OIL TEMPERATURE GAUGE
8. FUEL GAUGE
9. IGNITION SWITCH
10. STARTER BUTTON
11. HEAD-LIGHT SWITCH
12. SPOT-LIGHT SWITCH
13. BOOM EXTENSION INSTRUCTION PLATE
14. BOOM LEVER
15. WINCH CABLE LEVER
16. WINCH INSTRUCTION PLATE
17. CHOKE CONTROL
18. LIFT INSTRUCTION PLATE
19. SLEWING INSTRUCTION PLATE
20. LIFT LEVER
21. SLEWING LEVER

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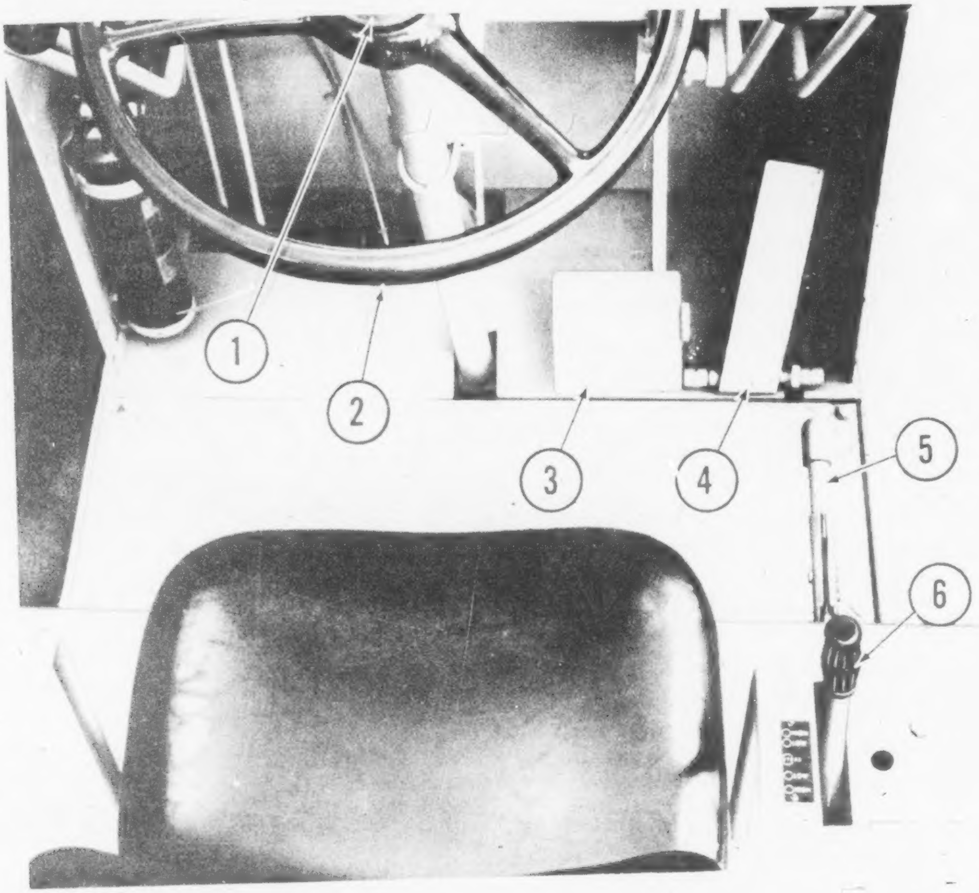
Figure 6-8.—Instrument panel, warehouse crane (Pettibone-Mulliken model 10F).



LEGEND:

1. HORN BUTTON
2. STEERING WHEEL
3. BRAKE PEDAL
4. ACCELERATOR PEDAL
5. PARKING BRAKE HAND LEVER
6. SHIFT LEVER

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Figure 6-9.—Operator's compartment, warehouse crane (Pettibone-Mulliken model 10-F).

in the transmission on a gage reading from 100° to 250°F.

The STARTER BUTTON (10) activates the starter to crank the engine. To start the crane engine, turn the IGNITION SWITCH (9) clockwise to ON and depress the starter button. When the engine starts, release the starter button. To stop the crane engine, turn the IGNITION SWITCH counterclockwise to the OFF position.

The purpose of the warehouse crane controls is explained below; the number in parentheses corresponds to those used in figure 6-9 to indicate the location of these controls.

The SLEWING LEVER (21), when pushed forward, swings the boom to the right. Pull the lever backward and the boom swings to the left.

The LIFT CYLINDER LEVER (20), when pushed forward, lowers the boom. Pull the lever backward and the boom raises.

The WINCH CABLE LEVER (15), when pushed forward, allows the cable to unspool from the cable drum. Pull the lever backward and the cable respools on the cable drum.

The CROWD LEVER (14), when pushed forward, extends the boom. Pull the lever backward and the boom retracts. Make sure the winch cable is down when extending the boom because the winch cable goes up when the boom is being extended.

The STEERING WHEEL (2) controls the direction of travel of the crane. Turn clockwise to move the crane in a right direction. Turn counterclockwise to move the crane in a left direction.

The SERVICE BRAKE PEDAL (3) is hydraulically controlled to aid in stopping the crane when pressure is applied by the operator. Release the pedal when putting the crane in motion.

The ACCELERATOR PEDAL (4) is used to increase or decrease engine speed. Depress the pedal to increase engine speed and release the pressure on the pedal to decrease engine speed.

The PARKING BRAKE HAND LEVER (5), when pulled up, applies the brake and holds the crane in a stationary position. To release the brake, push the lever down.

The SHIFTING LEVER (6) controls the forward and reverse movement of the crane. It also controls the four gears of the warehouse crane truck which are: low forward, high forward, low reverse, and high reverse. Neutral is midway between forward and reverse position. Push the lever halfway forward for low forward. Push the lever all the way forward for high forward movement of the crane. Pull the lever halfway back for low reverse. Pull the lever all the way back for high reverse movement of the crane.

When starting the warehouse crane truck, set the parking brake hand lever by pulling up on the lever. Make certain the forward-reverse shift lever is in the neutral position. Next, turn the ignition switch to the ON position, pull the choke control all the way out if the engine is cold, and depress the starter button which activates the starter to the crane engine. If the engine fails to start on the first try, allow the engine and starter to come to a complete stop before making a second attempt. After starting, hold the accelerator pedal steady and allow the engine to warm up at a fast idling speed. Immediately observe the engine oil pressure gage and ammeter for normal operation and readings. Also observe the transmission oil temperature gage for indications of trouble. As the engine begins to warm up, gradually push in the choke control. As soon as engine is warm, push the choke control all the way in.

Warm up the engine until it will idle smoothly with the choke all the way in. Check for proper readings on the ammeter, engine oil pressure gage, engine temperature gage, and fuel gage.

Remove foot pressure from the accelerator pedal. Report any malfunctions.

When ready to drive the crane, move the forward-reverse shift lever to the desired position, release the parking brake hand lever, and depress the accelerator pedal until the desired driving speed is obtained.

To pick up a load, maneuver your crane into position, stop the crane by depressing the brake pedal, and place the forward-reverse shift lever in the neutral position. Position the boom with the boom lift, crowd, and slewing control levers. Lower the hookblock over the material being loaded by pushing forward on the winch control lever. In order to save undue wear on the boom and for stability, the load should be lifted with the boom in the highest position possible. When the load is attached, the rigger will signal you to raise the load. Raise the load by accelerating the engine speed as you pull back on the winch cable control lever which will swing the load clear. When desirable, or necessary, you may then raise the boom. If the boom were raised before the hookblock, the load would be dragged along the ground, floor, or lower tier of material. The hookblock should not be raised so high that it becomes blocked or comes in contact with the boom head. Maximum height and swing of the boom are controlled by you.

Be aware, at all times, of the position of the boom and load.

As the load clears, place it into position by using the slewing control lever.

If the load must be carried further than the slewing boom can reach, it will be necessary to move the crane. The crane should not be moved until the load and the boom are in proper position for travel. In order to reduce the swing of the load, you should move the crane slowly and smoothly, avoiding sudden stops and turns. While the crane is traveling, you must not allow the load to swing too far. A free swinging load causes severe strain on all parts of the crane. When a crane travels loaded and there is danger of the load swinging, the rigger should attach a tag line to the load. The tag line is used to steer the load and control the swing of the load. Normally, the rigger will walk ahead of the loaded crane with the tag line guiding the load while giving necessary signals concerning travel.

After rigging the load for travel, place the forward-reverse shift lever in the desired position, release the footbrake pedal, and accelerate to desired speed. When you have maneuvered the crane into position for placing the load, use the slewing and crowd controls to center the load over the spot where it is to be placed. Then lower the load by moving the winch cable control lever to the forward position. A load should not be placed through the use of the boom only.

The rigger should guide the load into position as it is lowered and unhook the load allowing you to resume operations.

HAND SIGNALS

A uniform system of hand signals must be used on all materials-handling operations of a similar nature. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be located so as to be clearly visible to the operator at all times. The hand signals used in materials-handling operations are depicted in appendix I. It is important that you not only recognize and understand these signals when operating materials-handling equipment, but also be able to give them when called upon to act as a signalman on a materials-handling project.

SECURING

When securing a WAREHOUSE FORKLIFT TRUCK, position the forks for traveling, drive the forklift to the designated securing area, and position the forklift in a safe manner. After the forklift has stopped, lower the forks flush with the ground, set the parking brake, secure all accessories, allow the engine to idle a few minutes, and then secure the engine by turning the ignition switch to the OFF position.

When securing a ROUGH TERRAIN FORKLIFT TRUCK, position the forks for traveling, drive the forklift to the designated securing area, and position the forklift in a safe manner. After parking the forklift, lower the forks flush with the ground, secure all accessories, decrease engine speed, and allow the engine to run at half speed or lower for 4 to 5 minutes before closing the throttle and stopping the engine. After the engine stops, place the ignition switch in the OFF position. Drain the air tanks by opening the drain cocks.

When securing the WAREHOUSE CRANE TRUCK, position the hookblock and boom for traveling, drive the crane to the designated securing area, and position the crane in a safe manner. After the crane has stopped, move the forward-reverse shift control lever to the neutral position, apply the parking handbrake, allow the engine to idle, check all accessories, and secure the engine by turning the ignition switch to OFF position.

OPERATOR'S MAINTENANCE

Every Equipment Operator is required to perform certain daily maintenance services on materials-handling equipment which he operates. The faithful performance of these services does much to prolong the life of materials-handling equipment, to avoid major repairs and overhaul, and to ensure that the equipment will perform its mission consistently and dependably. Operator maintenance procedures for checking oil, battery and battery connections, coolant, fan belts, ignition and electrical systems, brake systems, and wheels and tires were covered in chapter 5 of this manual. Therefore, these maintenance procedures need not be repeated here.

LUBRICATION

Major maintenance or repair of materials-handling equipment generally will not be needed

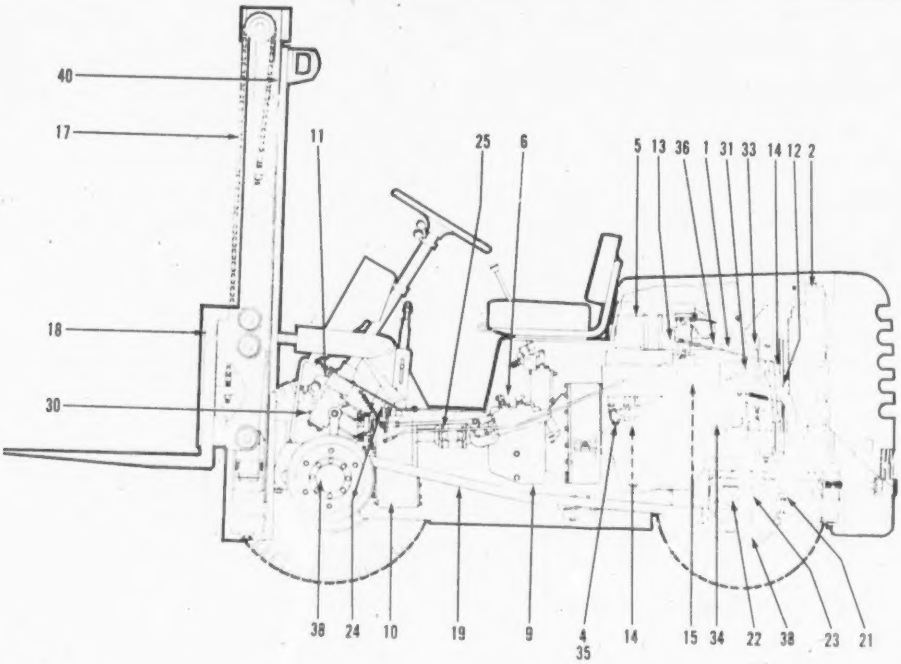

Figure 6-10. — Lubrication chart for warehouse forklift truck (Hyster "Monotrol" model). 115.441

for thousands of hours of operation, unless preventive maintenance service has been neglected. You can ensure proper maintenance by following guidelines set forth in the manufacturer's lubrication charts and service manuals.

A lubrication schedule for the Hyster "Monotrol" model of warehouse forklift truck is presented below. Figure 6-10 shows a maintenance and lubrication chart of this forklift truck. The numbers on the chart indicate individual points that require a particular service recommended by the manufacturer. (If a particular number does not appear on the lubrication chart, that service does not apply to that model of warehouse forklift truck being serviced.) A capacity chart showing the type and amount of lubricant to be used is given in figure 6-11.

In the schedule below, the numbers in parentheses correspond to the location numbers shown on the lubrication chart in figure 6-10.

1. EVERY 8 HOURS OR DAILY

Engine (1) — Check oil level. Add oil as as necessary (see fig. 6-11).

Air cleaner (5) — Check and service as necessary.

Radiator (2) — Check coolant level. Add coolant as necessary.

Fuel-Diesel (4) — Drain fuel from primary filter until clean fuel is emitted.

2. EVERY 50 HOURS OR WEEKLY

Engine (1) — Service crankcase breather, if so equipped.

Fan belts (12) — Check adjustment and condition of belts.

Hydraulic system (6) — Check oil level. Add oil as necessary (see fig. 6-11).

Brake master cylinder (11) — Check fluid level. Add fluid as necessary.

Transmission (9) — Check oil level. Add oil as necessary (see fig. 6-11).

UNIT	CAPACITY	TYPE		
Cooling System—Gas	16 Qts.	Winter: Water and Ethylene-Glycol base anti-freeze with rust inhibitors and anti-foaming qualities. Summer: Water with rust inhibitor.		
Diesel	13 Qts.			
Engine and Oil Filter		SAE No.	API Classification	Temperature
Gasoline/LPG	6 Qts.	30 20W 10W	MS MS MS	60° F & Above 32° F to 60° F 32° F & Below
Diesel	7½ Qts.	30 20-20W 10W	DS DS DS	80° F & Above 30° F to 80° F 30° G & Below
Differential				
Powershift	14 Lbs. (17½ Pts.)	SAE 90 AP		
Standard/Sp. Red.	18 Lbs. (21½ Pts.)	SAE 90 AP		
Transmission				
Powershift	12 Qts.	SAE 10 Type A		
Oil Clutch*	7 Lbs. (8½ Pts.)	SAE 140 AP SAE 90 AP		Below 30° F 30° F & Above
Fuel System	12.8 Gal.	Gasoline: Regular (84 Octane or better) Diesel: No. 2D Diesel Fuel		
Hydraulic System	12.5 Gal.	SAE 10W: API Classification—"MS", U.S. Military Spec.—MIL-L2104A, Viscosity Index (Min.)—90		
Steering Gear	1 Lb. (1¼ Pts.)	SAE 140 AP		
Brake Master Cylinder	½ Pt.	SAE 70 R3		

* Oil Clutch Transmissions with a hose from the flyweel housing to the transmission case use hydraulic system oil.

115.442

Figure 6-11. — Capacity chart for warehouse forklift truck (Hyster "Monotrol" model).

Speed reducer (10) — Check oil level. Add oil as necessary (see fig. 6-11).

Differential (7) — Check oil level. Add oil as necessary (see fig. 6-11).

Drive axle planetaries (8) — Check oil level. Add oil as necessary (see fig. 6-11).

3. EVERY 100 HOURS OR 2 WEEKS

Perform 50-hour services plus the following:

Engine (1) — Change lubricating oil (see fig. 6-11). Replace oil filter every second oil change.

Air cleaner (5) — Replace air cleaner element if it has been serviced 10 or more times.

Distributor (13) — Lubricate; check points.

Generator and starter (14) — Lubricate if equipped with fittings.

Battery (15) — Check and adjust electrolyte level. Clean and tighten terminal lugs.

Hoist chain (17) — Lubricate and check adjustment.

Load arm pins (18) — Lightly grease.

Uprights (40) — Raise uprights completely. Brush sliding surfaces with Lubriplate 130AA or equivalent.

GREASE THE FOLLOWING FITTINGS:

a. Drag link (19)
b. Steering booster (20)
c. Tie rods (21)
d. Center arm pivot (22)
e. King pins (23)
f. Brake linkage (24)
g. Drive shaft U-joints (25)
h. Pump drive shaft (26)
i. Carriage rollers (27)
j. Upright rollers (28)
k. Upright pivots (29)

OIL THE FOLLOWING POINTS:

a. All rod end pins
b. Chain anchors
c. Shift lever bushings
d. Throttle linkage
e. Parking brake cable
f. Hinges
g. Inching pedal linkage
h. Hoist and tilt control linkage

4. EVERY 500 HOURS OR 3 MONTHS

Perform 100-hour services plus the following:

Hydraulic system (6) — Check and clean tank breather.

Steering gear (3) — Check lubricant level. Add oil as necessary (see fig. 6-11).

Fuel-Diesel (31) — Replace secondary filter element.

Fuel-Diesel (33) — Replace final filter element.

Engine — Diesel (34) — Clean lubricating oil screen.

Fuel-Gasoline (35) — Clean filter bowl.

Injectors — Diesel (36) — Clean and check injectors.

5. EVERY 1,000 HOURS OR 6 MONTHS

Perform 500-hour services plus the following:

Standard transmission (not lubricated with hydraulic oil) (9) — Drain, flush, and refill with specified oil (see fig. 6-11).

Monotrol, hystamatic, powershift transmission (39) — Drain and refill with specified oil (see fig. 6-11).

Differential (7) — Drain, flush, and refill with specified oil (see fig. 6-11).

Drive axle planetaries (8) — Drain, flush, and refill with specified oil (see fig. 6-11).

Wheel bearings (38) — Clean and repack.

Radiator (2) — Drain, flush, and refill. Add rust inhibitor or antifreeze (see fig. 6-11).

6. EVERY 2,000 HOURS OR YEARLY

Perform 1,000-hour services plus the following:

Hydraulic system (6) — Replace hydraulic oil filters. Add oil as necessary (see fig. 6-11).

7. EVERY 5,000 HOURS OR 2 1/2 YEARS

Hydraulic system (6) — Drain, flush, and refill tank (see fig. 6-11).

A lubricating scheduling for the Pettibone-Mulliken model rough terrain forklift truck is presented in figure 6-12. This schedule indicates how often to lubricate, what to lubricate, and what lubricant to use. The lubricating chart shown in figure 6-13 indicates the points on this rough terrain forklift to be lubricated and provides a key to the symbol, type, and specification of lubricant to be used.

Figure 6-14 shows a lubricating chart furnished by the manufacturer of the Pettibone-Mulliken model wheel-mounted warehouse crane truck. The chart indicates the points on the warehouse crane truck to be lubricated, how often to lubricate, and what lubricant to use.

ADJUSTMENTS

Adjustment procedures for fan belts and hand-operated parking brakes used on materials-handling equipment which would normally be made by the TO, are basically the same as those given in chapter 5 of this manual for automotive vehicles.

SAFETY

Safety is a vital part of forklift truck operation. Many forklift safety practices are as simple and

Item No.	Lubricant Key	Quantity Required	8 Hours of Daily	40 Hours or Weekly	300 Hours or Monthly.	1000 Hours or Semi-annually	Part
1	BL	Hand brush		X			Inner and outer boom brush on mating surfaces
2	GAA	Press fitting gun			X		Outer boom grease fittings (2 places)
3	GAA	Press fitting gun			X		Drive shaft grease fittings (8 places)
4	GAA	Press fitting gun			X		Steering rod linkage grease fittings (10 places)
5	6090	Fill		O	X		Steering gear - maintain to level of plug
6	GAA E. O.	Press gun Hand lube.			X		Brake linkage grease fittings (2 places) and pivot points (1 place)
7	E. O.	Hand lube.			X		Shift and selector linkage pivot points (8 places)
8	E. O.	Hand lube.			X		Seat track
9	OHA	42 gal	O			C	Hydraulic system - maintain to level of dipstick
9	Clean	0			X		Breather cartridge - magnetic plugs
10	H. B.	Fill			X		Master brake cylinder maintain to fill
11	E. O.	3 qts		C			Air filter-remove sediment wash in diesel fuel and refill.
12	Water	26 qts	O				Radiator and engine.
13	Diesel fuel				C		Fuel strainer and fuel filter, replace cartridges and gaskets.
14	E. O.				C		Engine oil filter - replace cartridge and gasket
15	E. O.	15 qts	O		C		Crankcase oil - check daily with dipstick.
16	GAA	Press fitting gun			X		Pintle hook (3 places).
17	GAA	Press fitting gun			X		Oscillation pivot pins - grease fittings (4 places).
18	E. O.	Hand brush			X		Roller chain - clean with wire brush before oiling.
19	GAA	Press fitting gun			X		Carriage roller and sprocket grease fittings (18 places).
20	E. O.	Hand lube.			X		Accelerator and throttle linkage (14 places).
21	GAA	Hand brush		X			Brush chassis grease on exterior surface of axle ball joint - must be applied when wheels are turned to extreme left and right (4 places).
22	See Note 1 Fig. 6-14	Press fitting gun 20 pt each		O & X	C		Differential, front and rear - 20 pints each - new unit - maintain to filler plug.
23	GAA	Press fitting gun			X		Hydraulic cylinders - grease fitting (3 places).
24	9110	18 qts	O			C	Torque converter - 18 qts new unit - maintain to level of filler plug.
25	Diesel fuel	62 gal	O				Fuel tank.
26	9110				C		Transmission oil filter - replace cartridge
27	GAA	Press fitting gun				X	Front and rear axle ball joints - grease fittings (4 places).
28	E. O. GAA	Hand press gun			X		Hand brake pivot points (3 places) grease fittings (2 places).
29	See Note 1 Fig. 6-14	7 pts (4 places)		O & X		C	Planetary gear case 7 pts - new unit - maintain to plug level.
30	GAA	Press fitting gun		O & X			Flywheel flange seal (1 place).

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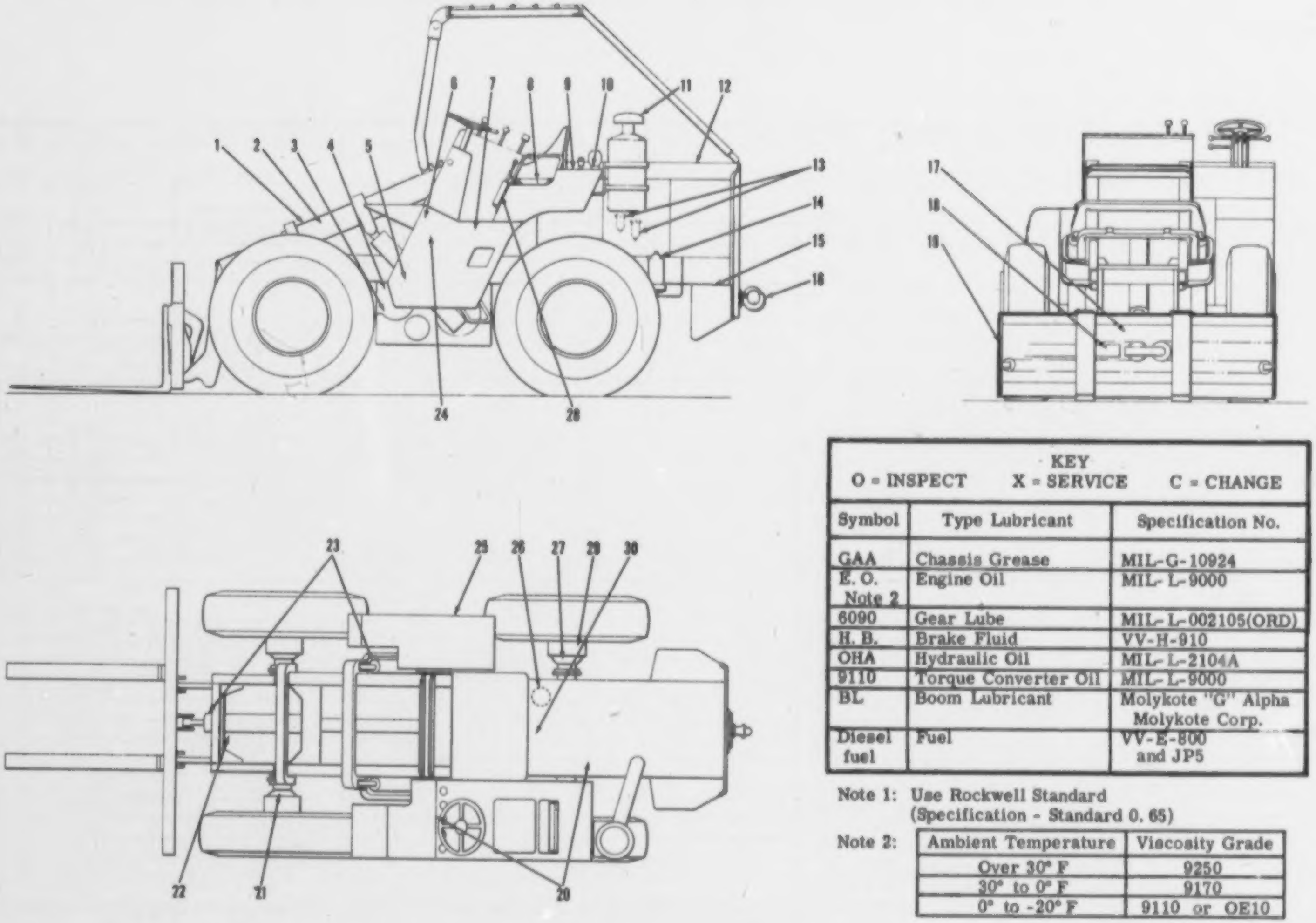
Figure 6-12. --Lubricating schedule for rough terrain forklift truck (Pettibone-Mulliken model OS-3354).



KEY
O = INSPECT X = SERVICE C = CHANGE

Symbol	Type Lubricant	Specification No.
GAA	Chassis Grease	MIL-G-10924
E. O. Note 2	Engine Oil	MIL-L-9000
6090	Gear Lube	MIL-L-002105(ORD)
H. B.	Brake Fluid	VV-H-910
OHA	Hydraulic Oil	MIL-L-2104A
9110	Torque Converter Oil	MIL-L-9000
BL	Boom Lubricant	Molykote "G" Alpha Molykote Corp.
Diesel fuel	Fuel	VV-E-800 and JP5

Note 1: Use Rockwell Standard (Specification - Standard 0. 65)

Note 2:

Ambient Temperature	Viscosity Grade
Over 30° F	9250
30° to 0° F	9170
0° to -20° F	9110 or OE10

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Figure 6-13.—Lubricating chart for rough terrain forklift truck (Pettibone-Mulliken model OS-3354).

obvious as driving the family automobile. For instance, before you start your car, you check to see if it is in neutral or park. When backing your car, you check behind you. When stopping your car, you do so gradually, not abruptly. However, since a forklift is a special machine designed to do much more than an automobile, and because of the close quarters in which forklifts operate, you must exercise more caution and receive additional training in order to operate a forklift properly.

You must be authorized to operate the forklift and thoroughly understand safety precautions. If you have had no experience in operating forklifts, you must make sure a qualified operator guides you through at least several operating and load handling operations before you attempt to operate the forklift on your own. This basic education in safe driving and load handling techniques is absolutely necessary to prepare you for proper defensive driving and enable you to anticipate the unexpected.

Safety precautions applicable to forklift operation are given below.

1. Avoid lifting or hitting anything that is likely to fall on you or other personnel in the area. Remember that a forklift equipped with an overhead guard and load backrest extension provides reasonable protection against falling objects, but cannot protect you against every possible impact. A forklift without an overhead guard provides no such protection. This means that you should never attempt to pick up any loose, unstable, or stacked load if it appears that any part of the elevated load might topple through or over the top of the upright, or fall on any personnel who happen to be standing nearby. It also means that to avoid hitting certain objects such as stacked material which could become dislodged and fall, you must exercise extreme care while working near such objects, and must not move your forklift around with the load carriage elevated. These rules apply whether or not your forklift is equipped with an overhead guard and they are of extreme importance for you if you are not protected by an overhead guard. These rules may result in reduction of load-carrying capacity, but they are absolutely necessary to ensure your protection.

2. When lifting personnel, use a secured safety platform. A forklift is built only for one rider — the operator. It is a safety hazard for anyone to ride the forks of your forklift or hitch a ride in any manner. If a forklift is used to elevate workmen, a safety platform must be secured to the forks. The platform should be specially built and secured to prevent its slipping from the forks, and it should have a solid floor and handrail.

3. Keep arms and legs inside the operator's compartment. Arms and legs outside the machine can be extremely dangerous in narrow aisles.

4. Keep yourself and all others clear of the hoisting mechanism. Never put hands, arms, head or legs through the upright or near the carriage or hoisting chains. This applies to both you and the rigger. A rigger should not be near the load or hoisting mechanism while you are attempting to pick up, hoist, or deposit a load.

5. Allow no one under the load or carriage, even if you have an overhead guard and your rigger does not.

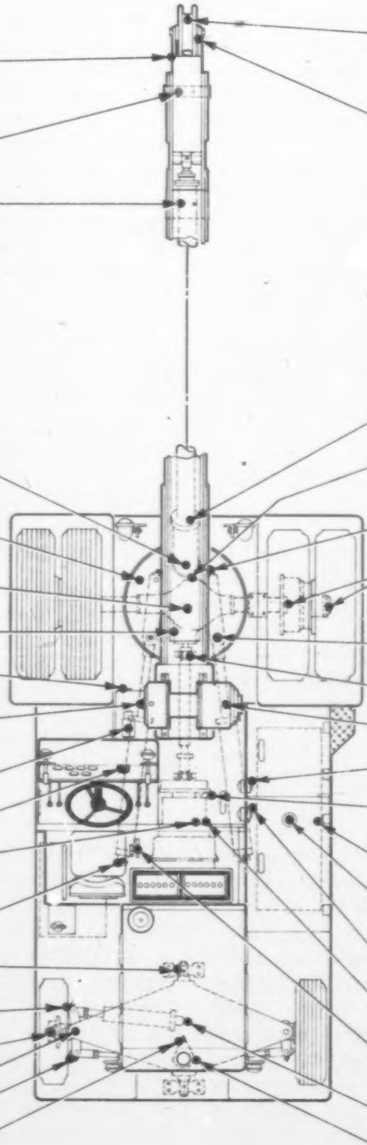
6. Report damage or faulty operation immediately — do not operate your forklift until the trouble is corrected. A forklift will only do its job safely when it is in proper working order. Your forklift should never be operated when a malfunction exists.

7. Avoid bumps, holes, slick spots, and loose materials that may cause your forklift to swerve or tip over. Different models of forklifts are designed to operate under different conditions. Although large forklifts can adapt to more uneven ground, it is still unreasonable to expect them to maintain their balance under abusive ground conditions. Try to pick the smoothest areas when moving material from one place to another.

8. Travel slowly around corners. Narrow aisles and blind corners are fine scenes for collisions. To avoid them, drive slowly and sound your horn in advance.

9. Lower the carriage completely, set the parking brake, and shut off the engine before leaving your forklift. Block the wheels when on an incline or working on the forklift. These rules apply under all conditions, even if you are only going to leave your forklift for a moment. A driverless forklift does not have to move far in close quarters to cause serious injury.

10. Do not turn on an incline. For stability reasons, a forklift should not be driven along the side of an incline so that the forklift leans sideways. Always keep the rear and front ends of the forklift pointed in the direction of the slant.



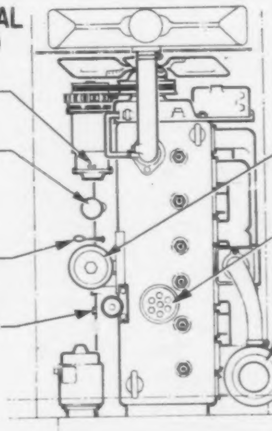
UNIT	LUBRICANT	INTERVAL (HOURS)
BOOM SHEAVE.	GAA	
BOOM WEAR SHOES.	GAA	250
BOOM ADJUSTING ROLLERS.	GAA	250
BOOM LIFT CYLINDER TUBE END.	GAA	250
TURNTABLE.	GAA	250
FRONT AXLE DRAIN PLUG (Drain & Fill).	GAA	500
SHIPPER PIVOT PIN.	GAA	250
HYDROVAC SERVICE PLUG (See Note 12).		500
WINCH FILL & LEVEL PLUG (Check Level and See Key).	GO	250
BRAKE MASTER CYLINDER (Check Level).	HB	250
BRAKE PEDAL PIVOT PIN.	GAA	250
TRANSMISSION & TORQUE CONVERTER DRAIN PLUG. (See Note 2).	OE	500
SLEWING CYLINDER TUBE END.	GAA	250
STEERING PILLOW BLOCKS.	GAA	250
STEERING CYLINDER ROD END.	GAA	250
REAR WHEEL BEARINGS.	GAA	500
STEERING SPINDLE.	GAA	250
TIE-ROD SPINDLE END.	GAA	250
STEERING LINK PIVOT PIN.	GAA	250

INTERVAL (HOURS)	LUBRICANT	UNIT
250	GAA	HOOK BLOCK SHEAVE.
250	GAA	HOOK BLOCK TRUNNION BEARING.
250	GAA	BOOM LIFT CYLINDER ROD END.
250	GO	DRIVE-AXLE FILL & LEVEL PLUG (Check Level and See Key).
250	GAA	SLEWING CYLINDER CONNECTING ARM.
500	GO	FRONT WHEEL BEARINGS (Lubricated from Drive Axle).
250	GAA	SLEWING CYLINDER ROD END.
250		DRIVE SHAFT UNIVERSALS.
500	GO	WINCH DRAIN PLUG.
500		HYDRAULIC OIL TANK FILTER (See Note 3).
500	OE	TRANSMISSION & TORQUE CONVERTER OIL FILL CAP (See Key).
1000		HYDRAULIC OIL TANK DRAIN PLUG (Drain & Refill)
40	OE	HYDRAULIC OIL TANK LEVEL CHECK & FILL CAP (See Note 8).
500		TRANSMISSION OIL FILTER (See Note 3).
8	OE	TRANSMISSION OIL LEVEL PLUGS (See Note 2).
250	GAA	TRANSMISSION SHIFT LEVER LINKAGE.
250	GAA	STEERING CYLINDER TUBE END.
250	GAA	TIE-ROD LINK PIVOT END

115.445.1

Figure 6-14. — Lubricating chart for warehouse crane truck (Pettibone-Mulliken model 10F).

UNIT	LUBRICANT	INTERVAL (HOURS)
GENERATOR (2 Oil Can Points)	OE	250
ENGINE OIL FILLER CAP (See Key and Note 6)	OE	250
ENGINE OIL LEVEL GAUGE (Verify Level)	NONE	8
ENGINE OIL DRAIN PLUG (See Note 4)	NONE	250



INTERVAL (HOURS)	LUBRICANT	UNIT
250	NONE	ENGINE OIL FILTER (See Note 7)
250	GAA	DISTRIBUTOR (See Note 9)
250	OE	AIR CLEANER (See Note 5)

KEY

LUBRICANTS	CAPACITY	EXPECTED TEMPERATURES			INTERVAL
		ABOVE +32°F	+40°F TO -10°F	0°F TO -65°F	
OE–OIL, ENGINE, HEAVY DUTY.					INTERVALS GIVEN ARE IN HOURS OF NORMAL OPERATIONS
CRANKCASE.	6 Qts.	OE-30	OE-10	OES	
HYDRAULIC OIL TANK.	248 Qts.	OE-10	OE-10	OES	
TORQUE CONVERTER and TRANSMISSION.	18 Qts.	OE-10	OE-10	OES	
GO–LUBRICATING OIL, GEAR.					
DRIVE AXLE.	12 Qts.	GO-90	GO-90	GOS	
WINCH.	4 Qts.				
HB–HYDRAULIC FLUID, NON-PETROLEUM BASE.		HB	HB	HB	
GAA–GREASE, AUTOMOTIVE and ARTILLERY.	ALL TEMPERATURES				
OES–LUBRICATING OIL, INT. COMBUSTION ENGINE.	ARCTIC				
GOS–LUBRICATING OIL, GEAR.	SUB-ZERO				
HBA–HYDRAULIC FLUID, NON-PETROLEUM BASE.	ARCTIC TYPE				

NOTES:

1. FOR OPERATION OF EQUIPMENT IN PROTRACTED COLD TEMPERATURES BELOW -10°F. Remove Lubricants Prescribed in the KEY for Temperatures Above -10°F. Clean Parts with SOLVENT, Dry Cleaning. Re-Lubricate with Lubricants Specified in the KEY for Temperatures Below 10°F.

2. TRANSMISSION, TORQUE CONVERTER-8. Verify Level with Engine Idling, Transmission in Forward Gear and Handbrake Set. 500 Drain when Hot. To Drain, Remove Transmission and Torque Converter Drain Plugs at Bottom. After Draining Replace Plugs and Refill.

3. HYDRAULIC OIL FILTERS-500. Remove Filter Element, Clean Filter Body and Install New Elements.

4. CRANKCASE DRAIN-250. Drain and Refill with Seasonal OE, Capacity 6 Quarts with Filter.

5. AIR CLEANER-250. Verify Level, 500 Drain, Clean, and Refill with Seasonal OE, Capacity 1 Pint.

6. CRANKCASE FILL-250. Clean Breather Cap.

7. ENGINE OIL FILTER-250. When Crankcase is Drained, Remove Filter Element. Clean Body and Install NEW ELEMENT.

8. HYDRAULIC OIL TANK-40. Check Level with Boom Down. To Check, Remove Breather Cap. Check Oil for Impurities (water, dirt). Every 1000 Hours Drain Tank, Clean Filter Element and Replenish with Clean Oil as Required.

9. DISTRIBUTOR-250. Wipe Breaker Cam Lightly with GAA. Lubricate Breaker Arm Pivot and Felt Wick with 1 or 2 Drops of Seasonal OE. Avoid Excessive Lubrication.

10. OIL CAN POINTS-250. Apply Seasonal OE to Throttle Accelerator and Brake Linkage, Also all Other FRICTION POINTS.

11. DRIVE AXLE BEARINGS. Lubricated Through Differential Filler Plug.

12. CHECK HYDROVAC. Check for Piston Lubrication Level Every 500 Hours. It Holds 2 Ounces of OE-10.

115.445.2

Figure 6-14.—Lubricating chart for warehouse crane truck (Pettibone-Mulliken model 10-F)—continued.

11. Do not fill the fuel tank while the engine is running. Fires and explosions can result from failure to follow this simple rule.

12. Sudden starts may damage various parts of the forklift, such as axles and gears, and cause excessive tire wear. Personnel in the vicinity may become injured and materials may be damaged by a forklift suddenly going into motion or going out of control.

13. Because a forklift is designed to perform such a wide variety of functions within limited space, there are certain clearance situations which you must anticipate. As an operator, you must be aware that the forks will sometimes protrude beyond the front of the load. Because of this you may strike objects or unintentionally lift or nudge other palletized loads. Many serious accidents have been caused by uprights and overhead guards colliding with pipes and beams connected to the ceiling in a warehouse. Because some forklifts steer by the rear wheels, the tail swings and can hurt personnel or damage property. And, most important, not watching in the direction of travel can easily result in damage to something or someone.

14. In the handling of loads, carefully observe the following precautions:

a. Handle only loads within rated capacity. The forklift nameplate rating indicates the maximum safe load that can be lifted. This maximum rating should never be exceeded. However, such factors as weak floors, uneven terrain, special load handling attachments for which the nameplate rating does not apply, or loads having a high center of gravity may mean the safe working load is considerably below the rated capacity. When special conditions do exist, you must reduce your load so that your forklift will remain stable.

b. Handle only stable loads. Many loads are made up of unstable items that can be easily dislodged. This rule has extreme importance for your safety when the forklift is not equipped with an overhead guard.

c. Center the weight of wide loads between the forks. Otherwise the load may topple off the forks when you turn a corner or hit a bump.

d. Watch "swing" when handling long loads. Failure to watch clearance at the ends of your load can cause you to strike persons or objects.

e. Keep the load against the carriage. This is most easily accomplished by maintaining a slight backward tilt.

f. Do not travel with the load raised any higher than 6 inches from the floor until you are ready to deposit the load. When loads are carried in an elevated position the stability of the forklift is reduced. There is also a possibility that the load or part of it can fall on someone or something.

g. For better vision with bulky loads, travel in reverse. Always keep a proper lookout in the direction of travel and always keep the load upgrade or grades of 10 percent or more. Normally, direction of travel should be determined by the best visibility available to the operator. This is why forklifts are built with reverse as well as forward travel. However, when grades of 10 percent or more are encountered both forklift and load stability demand that the load be kept upgrade.

h. Lift and lower with the mast vertical or tilted slightly back. Tilt elevated loads forward only when directly over the unloading place. If the load or lifting mechanism is elevated to pick up or deposit a load, keep the tilt in either direction to a minimum. But remember about side stability and don't tilt back any further than is necessary.

15. Drive carefully, observe traffic rules, and be in full control of the forklift at all times.

16. When securing a forklift, bring it to a gradual halt, place transmission in neutral, lower the forks to the ground, place the parking brake in the ON position, and shut off the engine.

Safety precautions applying to warehouse crane trucks during and after materials-handling operations are as follows:

Do not shift the directional shift lever while the crane is in motion.

Be alert for other personnel to be sure they are not in the way of the load or moving crane.

Be sure there is sufficient clearance overhead and on each side of the crane.

Avoid sudden starts and stops.

Reduce speed when making a turn.

Face in the direction of travel.

Know the rated capacity of the crane and do not exceed it. Never pick up a load until you are certain it can be carried safely.

Report any evidence of faulty crane performance.

Make sure the boom is lowered and placed forward of the machine when securing.

Raise the hooklock high enough that no one will walk into it.

Make sure the handbrake is engaged firmly when securing.

If crane is parked on an incline, block any two of the wheels in the event of handbrake failure.

CHAPTER 7

CONSTRUCTION AND MAINTENANCE EQUIPMENT

Before any piece of equipment is put into use on a job, you should become familiar with its capabilities and how it can be utilized to serve the purpose for which designed. This chapter contains such information for miscellaneous types of construction and maintenance equipment, including floodlights, generators, lubricators, pumps, rotary street sweepers, and magnetic street sweepers. Information is also given on safety precautions to be observed when working with this equipment.

FLOODLIGHTS

Floodlight equipment used by the SEABEES is especially designed to operate under adverse conditions. Since there are different makes and models of floodlights in use, we will discuss in this section the Essex Electric Engineer's model A172, shown in figure 7-1.

This unit is intended for field application under all kinds of climatic conditions. Being self-contained, it is especially suited for use in remote locations as an emergency floodlight source. The floodlight set also has sufficient capacity to supply power for small handtools, in addition to normal floodlight load.

The basic unit consists of an engine generator set, six portable floodlights, eight extension cords, and a control panel containing a voltage regulator, output ammeter, output voltmeter, circuit breakers, and output receptacles. All of the components are mounted on a two-wheel trailer covered by a weatherproof sheet-metal housing.

The six portable floodlights are rated at 500 watts each and utilize a rough service incandescent lamp. Mounting provisions for the floodlights are provided inside the housing for storage and on top of the housing for use during operation. The floodlights are capable of being swiveled in different directions and pivoted in various positions. Eight, 100-foot extension cords are supplied for using the floodlights away from the unit.

The control panel for the generator and floodlights (fig. 7-2) is located at the rear of the unit. The panel is divided into two sections: (1) A top section containing the output voltmeter, output ammeter, control fuse, field flash switch, panel light switch, voltage control, main 60-amp circuit breaker, and eight 15 amp receptacle circuit breakers; and (2) a lower section containing eight weatherproof receptacles.

The trailer is a two-wheel unit which has a retractable front stand, safety towing chains, parking brake, lifting eyes, adjustable coupling, and 12-volt vehicle lighting system.

Safety is a vital part of floodlight operation. Many floodlight safety practices are simple and obvious. Safety precautions applicable to floodlight operation and care are given below.

1. Inspect floodlight units for security of connections, particularly in fuel and electrical systems. If connections, parts, bolts, nuts or other hardware have been loosened, tighten them.
2. Inspect meter glasses, lights, extension cords, and other parts for damage.
3. Always pipe exhaust fumes outside when operating a floodlight unit in an enclosed area.
4. Always stop the unit before servicing with fuel or lubricants.
5. Do not allow extension cords to come in contact with sharp objects, oil or grease, hot surfaces, or chemicals.
6. Extension cords should not be allowed to kink, nor be left where they might be run over.
7. Replace damaged cords. They are NOT to be patched with tape.

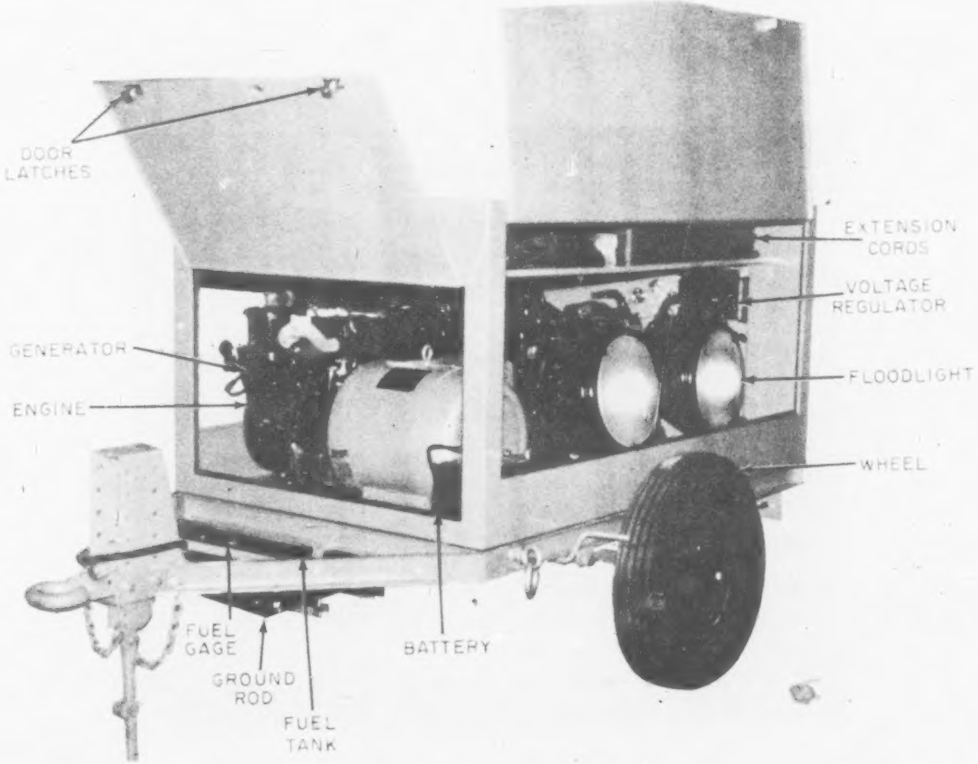


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Figure 7-1. — Portable floodlight unit.

8. Store cords in their proper place, loosely coiled.

9. Do not attempt to install, hookup, or place any of the electrical apparatus when you have wet hands, or when wearing wet clothing or shoes.

10. Whenever it becomes necessary to check a circuit, have a CE do this using appropriate testing equipment.

CAUTION: NEVER SHUT DOWN THE PRIME MOVER WHILE THE GENERATOR IS UNDER LOAD.

GENERATORS

At overseas bases, generators are used to provide power for electrical loads for camp and project lighting, communications, power equipment, and so on. The SEABEES use various makes and models of generator sets. However, for purposes of this discussion, information on the Cummings model JS-6-G (60 kw-ac) generator set, shown in figure 7-3, will be given.

The model JS-6-G generator set is a self-contained, skid-mounted unit. The unit is provided with controls, instruments, and accessories necessary for independent operation.

The Cummings diesel engine is a six-cylinder, overhead-valve, liquid-cooled, supercharged, four-cycle engine, and is governed at a speed of 1,500 to 1,800 rpm. The engine drives the generator unit directly from the flywheel.

The generator set is a combination of an engine and an electric generator which converts mechanical energy into electrical energy.

The Construction Electrican will make the selection of generating equipment. His selection

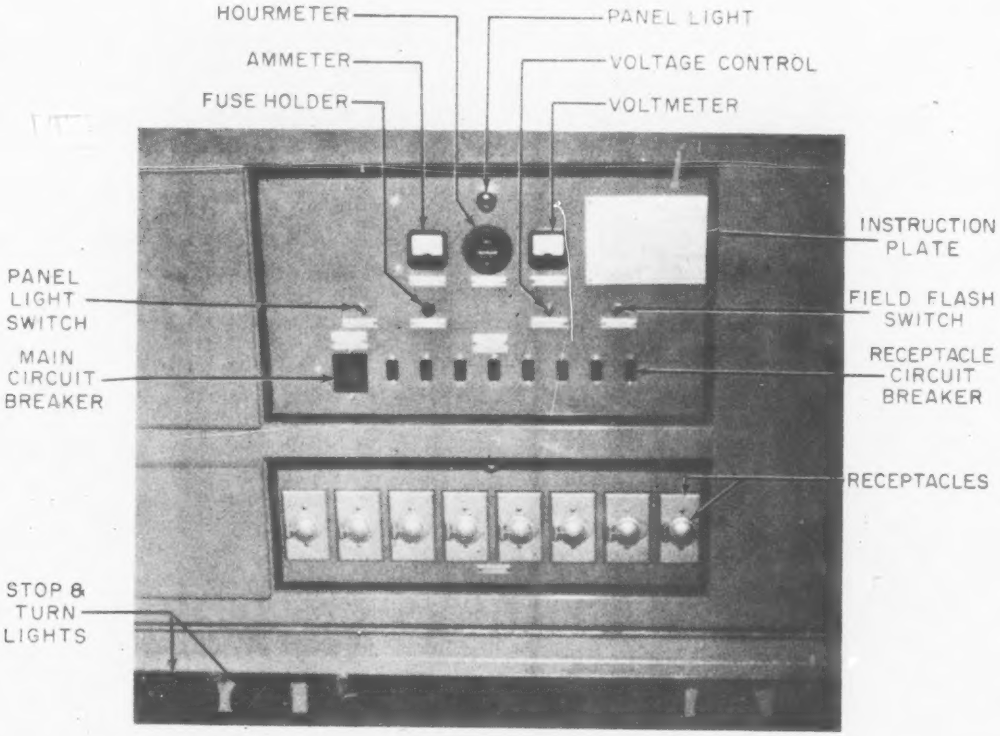

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Figure 7-2. — Portable floodlight unit control panel.

will be based on the electrical demands, voltage phase, and frequency requirements.

Usually, the generator site is located on a level, dry, and well-drained area close to the point of largest demand for electrical power. This is to reduce the size of wire required, hold line losses to a minimum, and afford adequate voltage control at the remote end of the line.

Safety precautions must be observed when working with or near generating equipment. A severe or fatal shock can result from coming in contact with any part of the electrical system during its operation.

Upon installation of a generator set, it is vitally important that the unit be grounded before placing an electrical load on the system.

When you service (add fuel or lubricants) to the generator set, make sure the unit is shut down and not attached to an energized line.

CAUTION: NEVER SHUT DOWN THE PRIME MOVER WHILE THE GENERATOR IS UNDER LOAD.

In case of an accident from electric shock, shut down the generator set at once. If the set cannot be shut down, free the victim from contact by using a nonconductor, such as a dry board or a dry rope, while avoiding contact with the victim. If the victim is unconscious, apply artificial respiration until medical help arrives.

LUBRICATORS

Many different types of lubricators are used by the Navy. You will find, however, that most of the Navy's lubricators are the portable skid-, truck-, and trailer-mounted types.

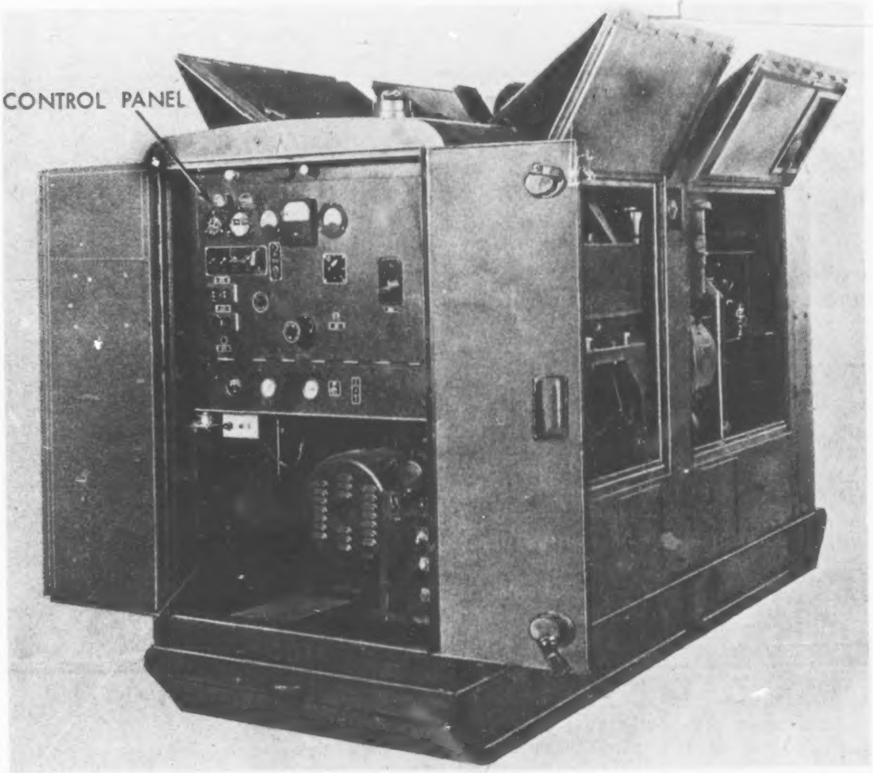

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Figure 7-3.—Generator, 60 kw-ac.

Here we are concerned primarily with the portable skid-mounted type. Although the information here applies to the Graco model 252-538 portable, power-operated lubricating and servicing unit (fig. 7-4), much of the information will also apply to other makes of lubricators. For specific instructions, follow those provided by the manufacturer of the equipment concerned.

When automotive and construction equipment are being utilized on a project site some distance from the maintenance shop, the portable self-contained lubricator can be used to save the time and expense that would be involved in moving the equipment long distances to be lubricated and serviced.

The lubricator can be used to grease fittings, dispense lubricating and gear oils, and inflate and gage tires.

To grease fittings, pull out the length of lubricating hose required, wipe fittings clean, and push the coupler of the control valve onto the fitting. Squeeze the valve lever. When all old grease has been forced out, release the lever and twist the coupler to one side and remove it. After thorough servicing, wipe the control valve coupler clean, rewind the hose, and return the control valve to its holder.

To fill the engine crankcase or gear housings with lubricant, pull out the necessary length of dispensing hose. Then clean the fill opening of all dirt, remove the cap or plug, insert the control valve nozzle, set the meter to zero, and squeeze the valve lever. When the proper level is reached, release the valve lever, clean the control valve nozzle, reset the meter to zero—turn counterclockwise—and return the dispensing hose to its holder.

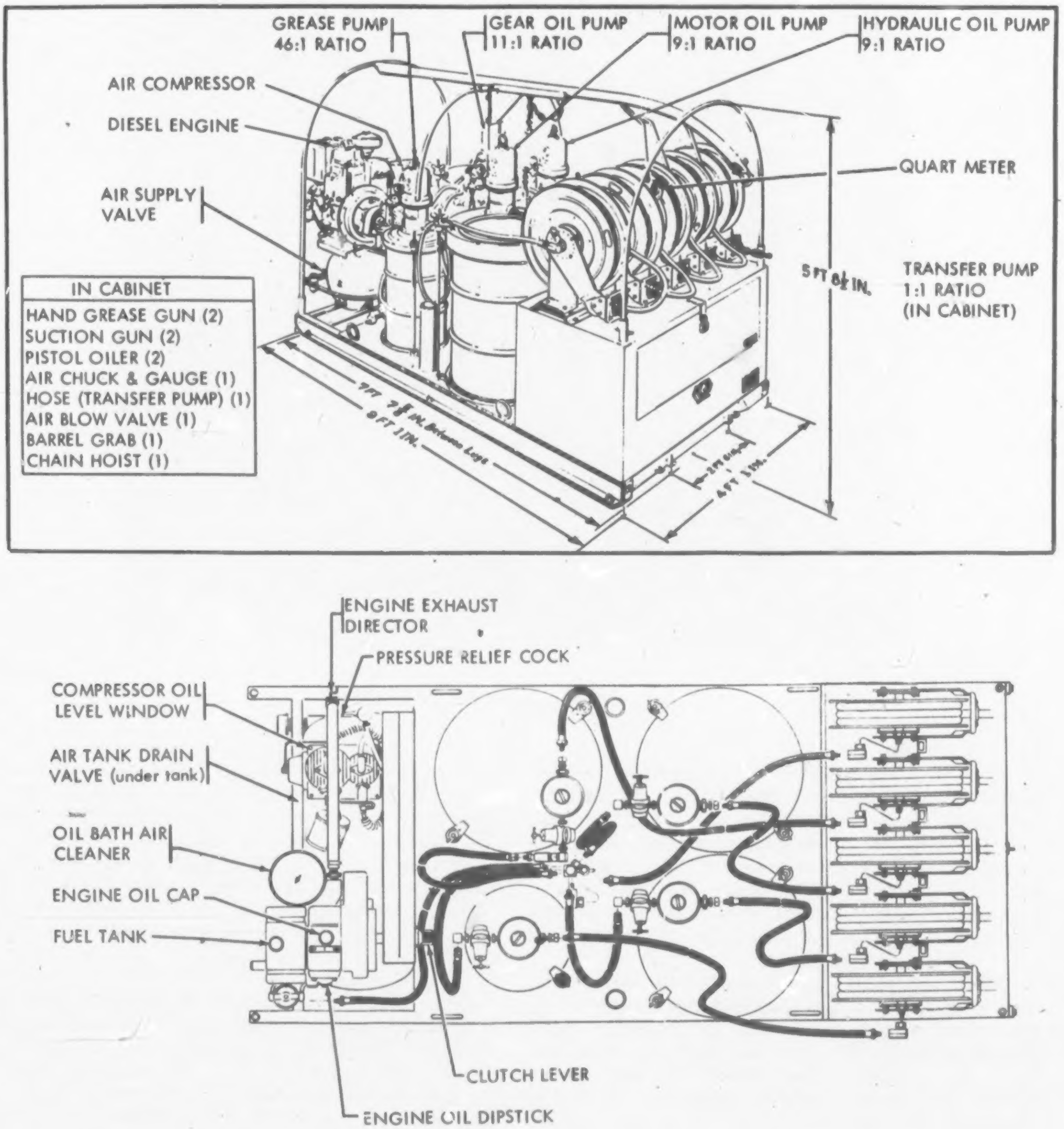

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Figure 7-4. — Portable lubricating unit.

To inflate and gage tires, use the air gage equipped with two sizes of air chucks. The gage has a pin fitting which snaps into the airhose coupler. When inflating tires, release the gage lever to check pressure; depress to inflate.

Additional equipment in the storage cabinet consists of two pistol-type hand oilers for oilcan points, two suction guns for emptying reservoirs without drains, two lever-operated grease guns for small servicing jobs, and an airflow gun for cleaning assorted fittings and fill plugs.

When working with lubricating equipment and before filling the fuel tank of the lubricator, make sure the engine is turned off and see that you have firm metal-to-metal contact during filling. The engine should also be turned off before adding lubricants.

Pipe exhaust fumes to the outside when operating the lubricator in an enclosed area.

Stand to one side when inflating a tire.

Do not direct a jet of compressed air at yourself or anyone else.

Use Navy-approved solvents for cleaning.

Relieve all pressures before servicing any component of the lubricator.

PUMPS

A pump is a device which uses an external source of mechanical power to move liquid from one point to another. To accomplish this, the pump may employ a pushing, pulling, or throwing motion. In this connection, pumps are often named or classified according to the type of movement that causes pumping action; for example, diaphragm, centrifugal, or rotary.

Regardless of its design or classification, each pump has a power end and a liquid end. The POWER END is some form of prime mover, such as an electric motor, internal combustion engine, or steam turbine. In steam driven pumps, the power end is often referred to as the steam end. The basic purpose of the power end is to develop the mechanical motion or force required by the liquid end.

The LIQUID END is that part of the pump where mechanical motion or force developed by the prime mover is actually exerted on the liquid. This part of the pump must have provisions for suction (where the liquid enters) and for discharge (where the liquid leaves the pump). The liquid end is often referred to as the pump end. It may also be called the water end or oil end to indicate the nature of the substance being pumped.

DIAPHRAGM PUMPS

Diaphragm pumps (fig. 7-5) employ a flexible diaphragm to move liquid. The prime mover is usually a small gasoline engine with an eccentric connecting rod arrangement which converts rotary motion to reciprocating motion. On the suction stroke, the diaphragm is drawn upward into a concave configuration. This movement of the diaphragm results in a partial vacuum which causes the suction ball valve to unseat (and at the same time keeps the discharge ball valve seated) and admit liquid to the pump cylinder. On the discharge stroke, the diaphragm is pushed downward, forcing the trapped liquid out through the discharge valve. Thus, the liquid is made to move by the reciprocating motion of a flexible diaphragm.

Since the diaphragm forms a relatively perfect seal in the pump cylinder, between the liquid

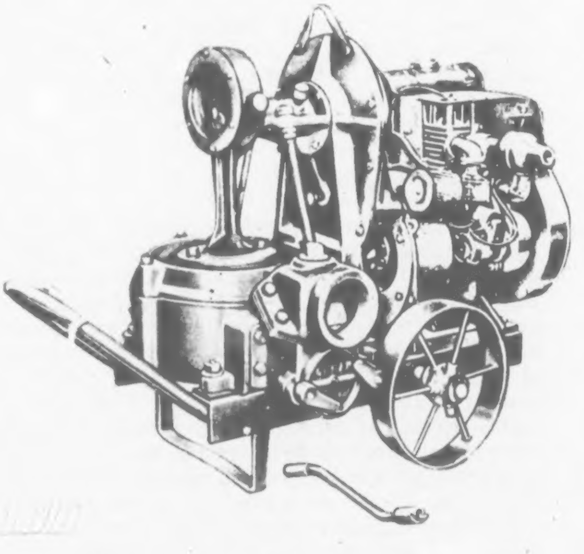

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Figure 7-5. — Portable diaphragm pump.

being pumped and the rest of the pump and driving mechanism, there is little danger of liquid abrasion or corrosion of moving parts behind the diaphragm. For this reason, diaphragm pumps are especially well suited for pumping mud, slime, silt, and other wastes or heavy liquids containing debris such as sticks, stones, or rags. Liquid strainers are, however, fitted at the suction inlet to prevent large objects from fouling the suction and discharge valves or possibly damaging the diaphragm.

You may have occasion to use the diaphragm pump for such duties as dewatering trenches where sewerlines or waterlines are to be laid, dewatering cofferdams or cave-ins, or when repairing breaks in water or sewage lines.

Two of the most popular types of diaphragm pumps are the mud hog (closed discharge) and the water hog (open discharge). The MUD HOG is suitable for jobs that require pumping heavy and thick liquids which must be discharged at a distance away from the pump. The pump is fitted with discharge hose connections, and the ball valves and chambers are designed to prevent fouling by sticks, stones, or rags.

The WATER HOG is used for pumping thinner or less viscous liquids. It can handle liquids containing sand, gravel, or mud. The discharge outlet from the water hog is open to permit free flow and increase discharge capacity. The liquid is discharged directly at the pump. A discharge hose, however, can be fitted to the pump if desired, but this hose connection can reduce its efficiency.

CENTRIFUGAL PUMPS

The basic centrifugal pump (fig. 7-6) has only one moving part: a wheel or impeller which is connected to the drive shaft of a prime mover and which rotates within the pump casing. The design or form of the impeller may vary somewhat. However, whatever its form, the impeller is designed to impart a whirling or revolving motion to the liquid in the pump. When the impeller rotates at relatively high speeds, sufficient centrifugal force is developed to throw the liquid outward and away from the center of rotation. Thus, the liquid is sucked in at the center or eye of the impeller (center of rotation) and discharged at the outer rim of the impeller.

The advantages of centrifugal pumps include simplicity, compactness, weight saving, and adaptability to high-speed prime movers. They have their widest application in water supply and distribution systems at shore facilities.

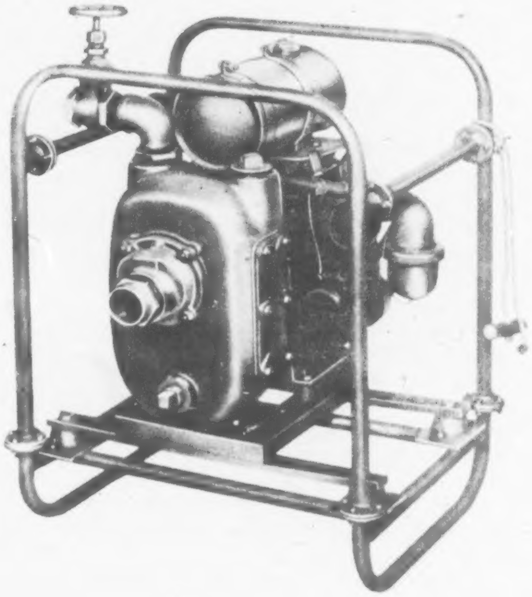

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Figure 7-6. — Standard 125-gpm centrifugal pump.

ROTARY PUMPS

All rotary pumps employ the principle of entrapment and displacement of fluid by rotating elements of various design. These rotating parts, which may be gear teeth, screws, lobes, vanes, etc., trap the fluid at the suction inlet and remove it to the discharge outlet. Instead of "throwing" the water as in a centrifugal pump, a rotary pump traps it, pushes it around inside a closed casing, and discharges it in a continuous flow. Since rotary pumps move liquid according to this method, they are often classified under the broad heading of positive displacement pumps.

The simplest type of rotary pump is the GEAR PUMP, shown in figure 7-7. This type of pump employs two spur gears which rotate in opposite directions and mesh together at the center of the pump. One of the gears is coupled

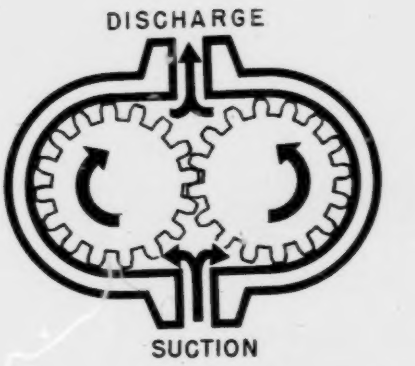

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Figure 7-7. — Gear-type rotary pump.

to the prime mover (usually an electric motor) and is called the driving gear. The other gear, which receives its motion by meshing with the driving gear, is called the driven gear. It is important to note that the actual movement of liquid is accomplished as the gear teeth rotate against the casing of the pump, thereby trapping the liquid and pushing it around to the discharge outlet. The meshing together of the two gears does not in itself move or pump liquid. The meshing of the gear teeth, in effect, forms a constant seal between the suction and discharge sides of the pump and thus prevents liquid from leaking back toward the suction inlet.

Generally, rotary pumps are considered to be self-priming; that is, the pump end need not be filled with liquid in order to initiate pumping action. Instead, the movement of the rotating elements will create a partial vacuum sufficient to lift or draw liquid into the pump and initiate the pumping process. It should be noted that self-priming and good suction lift are actually characteristics of the whole class of positive displacement pumps.

Rotary pumps have the added advantage of being less expensive and considerably simpler in their construction than other types of pumps.

SAFETY PRECAUTIONS FOR PUMPS AND PRIME MOVERS

In working with pumps and their prime movers it is essential that you exercise care to avoid injury to anyone. Here are some safety precautions which you should observe.

1. Before operating or beginning work with pumps, make sure that all suction and discharge valves are closed and tagged.
2. Inspect for security of connections, particularly in the fuel system of the prime mover.
3. Ensure that the ignition switch is in the OFF position before performing operational checks or attempting any repairs.
4. Disengage clutch (where provided) between prime mover and pump.
5. See that exhaust fumes are piped outside when pumps are to be operated in an enclosed area.
6. Stop operations before adding fuels or lubricants, either to the prime mover or the pump.

ROTARY STREET SWEEPER

The Navy uses different types of rotary street sweepers, the most common being the self-propelled type. Figure 7-8 shows the Wayne model 900 series self-propelled, rotary street sweeper. This sweeper is used primarily to remove loose debris from the surface of streets, roads, parking areas, taxiways, and airport runways. It can also be used to remove dust from the surfaces of an existing pavement prior to resurfacing; this will help ensure proper bonding between the newly laid asphalt and the old surface.

Plan ahead by selecting routes where water is available during sweeper operations to refill the sweeper's water tank. This will save the time and expense that would be involved in traveling long distances to accomplish the refilling task.

The sweeper is equipped with a prime mover, controls, and devices for controlling movement of the basic machine for steering; sweeping; water spraying; and picking-up, containing, and disposing of debris.

When refueling a rotary street sweeper, make sure the engine is turned off and see that you maintain metal-to-metal contact with the fuel tank and fuel nozzle.

Keep personnel away from sweeper brushes and scrubbers during operation.

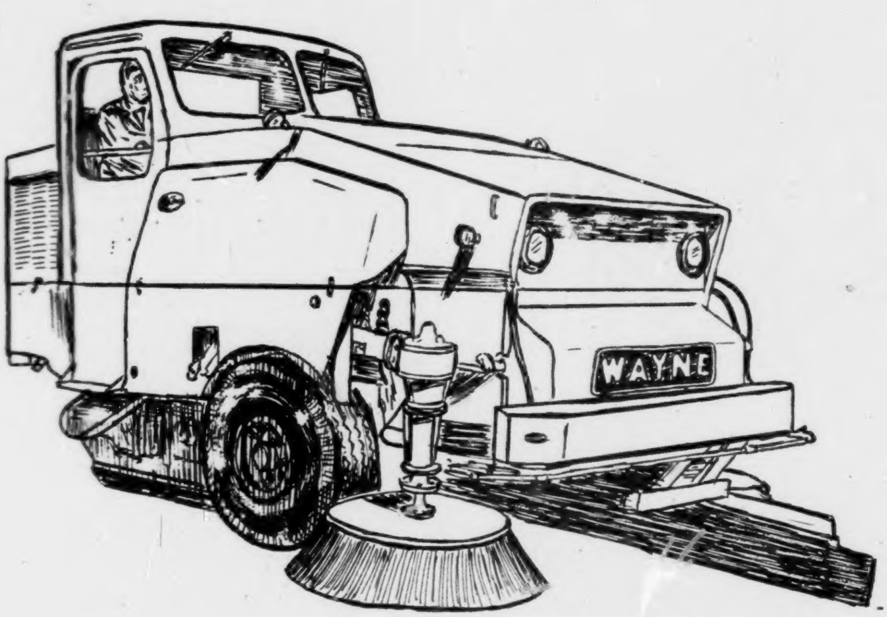

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Figure 7-8.—Self-propelled rotary street sweeper.

Always stop operations when adjusting, cleaning, and lubricating the equipment.

Keep hands clear of drive chains.

Park sweeper on level ground with handbrake applied.

Don't turn the steering wheel sharply when the machine is in motion. The sweeper is very responsive to movement of the steering wheel—so avoid sudden turns, except in emergencies.

MAGNETIC STREET SWEEPER

The magnetic street sweeper is used primarily to magnetically pick up metal debris, such as iron and steel scrap, from traffic areas.

The Consolidated Diesel Electric Corporation model Z100, shown in figure 7-9, is one of many different makes and models of self-propelled magnetic street sweepers used by the SEABEES. This type of sweeper is most effective in warehouse and storage areas, and on granular or earth surfaces, which cannot be cleaned with broom equipment.

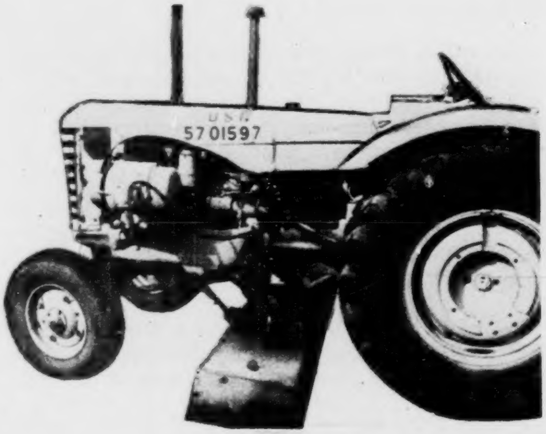

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Figure 7-9.—Self-propelled magnetic street sweeper.

Using the magnetic sweeper one or two times a week, under normal conditions, is sufficient to keep areas free of metal debris. If building or warehouse demolition is in progress, the magnetic sweeper should be used throughout the day as needed to keep areas free of metal debris.

By positioning the hydraulically controlled lever, the operator can adjust the height of the magnet for the type of surface being magnetically swept. Heavy springs and a bumper mounted on the front of the magnet help prevent magnet damage when an obstruction is encountered during operation. The springs act to lift the magnet over an obstruction, and return the magnet to its previous position.

After sweeping an area, be sure to take the magnetic sweeper to an assigned trash area, dump the debris collected by shutting off the magnet circuit breaker, and place the debris in the container provided.

When refueling a magnetic street sweeper, make sure the engine is shut off and see that you maintain metal-to-metal contact with the fuel tank and fuel nozzle.

Allow no riders other than the operator.

Stop operations when adjusting, cleaning, and lubricating the unit.

Do not drop material from the magnet and then run the sweeper over the material. Pick up the material and dispose of it before securing the sweeper.

SNOWPLOW SAFETY

As an Equipment Operator, you may be required to use snow removal equipment. Therefore, you should be familiar with important safety precautions which will prevent personnel hazards and equipment failure. Major precautions to be observed are as follows:

All vehicles, including the radio-equipped lead vehicle operating in snow removal areas, should carry standard warning flags. In addition, areas of heavy snowfall require markers to be placed at drainage structures, low points of open water, hydrants, curb ends, guardrails, and other required points. Markers guide plow operators, help avoid damage to equipment and the object marked, and aid in locating structures so that drainage may be restored and services resumed after storms.

Obstructions such as rock, stockpiles, and ridges of material must be removed from areas to be plowed.

Blade shoes and rollers must be adjusted to clear snow to the pavement when the surface is smooth. Plow blades should be raised from 1/2 to 1 inch for plowing uneven pavements, and raised 2 inches or more for rough surfaces, airfield aprons equipped with flush-type or surface-level utility outlets, and turf-covered areas. The blades should be lifted to prevent damage that may occur when crossing railroad tracks, curbs, or other low obstructions.

Personnel should be kept clear of plows equipped with rotating shafts, blades, and augers.

All plow accessories, such as high-mounted headlights, clearance lights, spot lights on front and rear, heaters, defrosters, and double windshield wipers, must be maintained properly.

An EO assigned to a specific unit generally receives instructions on the operating, care, and handling of the equipment and attachments. Make sure you thoroughly understand and carefully observe these instructions.

CHAPTER 8

PRINCIPLES OF EARTHWORK

The practical operation of a road, runway, or taxiway requires that it be built within definite limits of grade and alignment. The irregularities of the ground must first be removed or lessened by cutting off high spots and filling in low places. This cutting and filling process, commonly known as either EARTH-MOVING, GRADING, or EARTHWORK, is particularly heavy on runways because they require level grades and less abrupt changes of grade than are allowed for roads and taxiways. In construction of roads and airfields, earthwork is considered the most important operation since it takes considerable effort in relation to men, time, and equipment.

In this chapter we will explain some of the basic principles of earthwork. We will also describe some common types of equipment used in earthwork operations. In addition, we will explain how a typical equipment operation is planned from a freehand sketch of a proposed construction site.

Earthwork construction in a theater of operations is nearly always restricted to rough, hasty work, because roads and airfields built in advanced areas are primarily for immediate needs and of a temporary nature. Certain basic principles must be adhered to, but time limitations restrict the operations to bare essentials. Emphasis is placed on rapid construction. Such factors as convenience, appearance, and cost, which are important in civil and peacetime construction, are subordinated. Speed and simplicity are fundamental in advanced-area earthwork construction, and both are achieved by undertaking only the work that is necessary to meet the minimum requirements of the job.

JOB EFFICIENCY

There is more to earthwork operations than just moving the earth. As an EO you must know what the finished job will look like. Studying and understanding project plans, developing sketches, and knowing your equipment will enhance your ability to move earth efficiently.

PLANS

When your crew has been assigned a road project involving earthmoving, the project officer or operations department will furnish your crew leader with a set of blueprints of the project. Normally, these blueprints will include a set of plan and profile sheets. An example of a typical plan and profile sheet is shown in figure 8-1. The top half of this sheet shows the plan of a proposed road which includes information such as road alignment, distance in 100 feet stations, and other locations of structures in relation to the proposed road. The bottom half of the plan and profile sheet shows a centerline profile in relation to the plan view. The profile indicates the existing ground elevation along with the proposed centerline road elevation. When the project is larger and more detailed, the plan and the profile are on separate sheets. By carefully comparing the plan and profile sheets with the actual field conditions, you can visualize the finished road and start planning your work to accomplish the required task.

FREEHAND SKETCHES

The use of freehand sketches will help you to plan your work. A freehand sketch is a drawing which is made without the use of mechanical aids or devices. However, sketches may be drawn on graph paper, traced, or drawn with a straightedge. A sketch may be of an object, an idea, or a combination of both. The ability to make quick, accurate sketches is very helpful in conveying your ideas to others. You need not be a draftsman or an artist to prepare working sketches. Sketches which you will prepare may be for your own use or for use by other crew members.

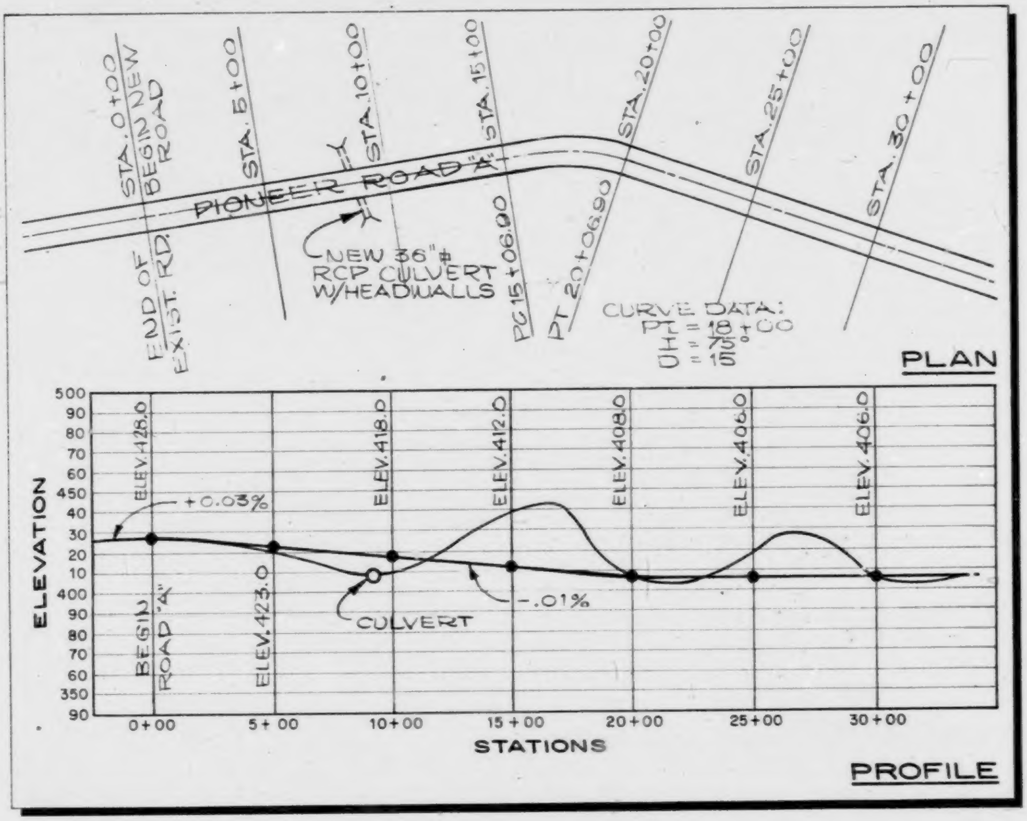

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Figure 8-1. — Plan and profile sheet.

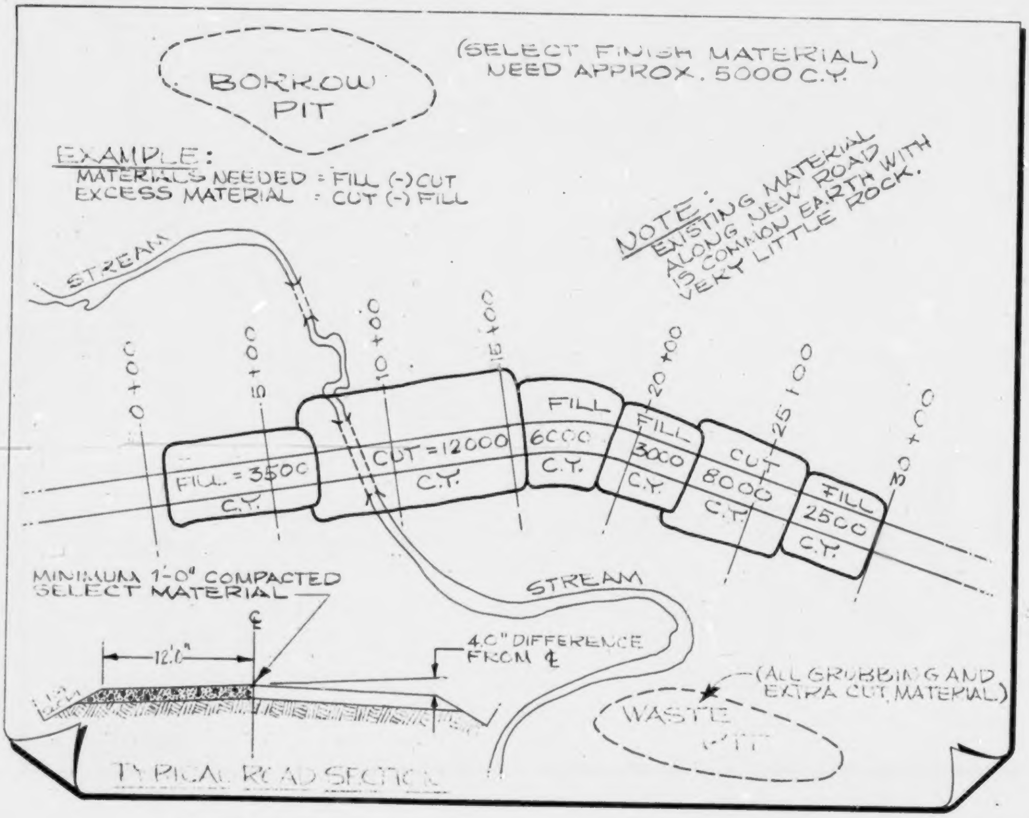
Two examples of freehand sketches are shown in figures 8-2 and 8-3. These sketches were developed from the original plan and profile sheet of a typical road project illustrated in figure 8-1.

These sketches depict different earthwork phases to be considered by the EO when engaged in earthmoving operations.

The sketches shown in figures 8-2 and 8-3 were prepared by placing a piece of tracing paper directly over the plan and profile sheet shown in figure 8-1 and tracing the new road and stationing. Information was added which was not included on the original plan and profile sheet; such as, borrow pit, waste pit, stream, temporary haul road, temporary culverts, equipment area, planned cut and fill areas, and a typical road section. Freehand sketches are prepared by the supervisor responsible for the job. Therefore, any information may be included which will make the project more understandable. By following the above procedure, you should be able to sketch freehand from any plans covering earthwork operations. Sketches need not be prepared in great detail.

EQUIPMENT

Knowing your equipment, its limitations, and its operating characteristics are part of the knowledge you must acquire to become an efficient operator on earthmoving jobs. After having operated equipment for a while, you will be able to tell whether you have picked up a full load, and whether or not you are losing it. You will know when you are digging too deeply, and when you are cutting smoothly. You will learn to depend upon your sense of feel and on the sound of the



115.447

Figure 8-2.— Plan overlay sketch emphasizing cut and fill areas.

engine in controlling your equipment. No matter what type of equipment is in use, knowing its characteristics will help you to become a good productive operator.

Before earthmoving begins, it is frequently necessary to remove overgrowth, boulders, and other obstructions. Also, it is often necessary to construct a drainage system so that the construction site will drain. These operations are carried out with bulldozers, power shovels, scrapers, graders, rippers, and similar equipment.

When you are moving earth, take a full, heaped load and make it count. In earthmoving operations, travel can be one of the most time-consuming factors. Suppose you are operating a tractor-drawn, 12 cubic yard scraper. It will carry about a 15 cubic yard heaped load (fig. 8-4). If you carry only a struck (level) load of 12 cubic yards, you lose 3 cubic yards of load each trip. To move 60 cubic yards takes 5 trips, hauling 12 cubic yards each time. Hauling full heaped loads, you would move the same amount of earth in 4 trips. If the haul is short and units are waiting to get into the cut, it will increase production to take only a GOOD load (somewhere between struck and heaped) and move out, rather than to spend extra time obtaining a heaped load.

EARTHWORK OPERATIONS

Earthwork consists of various operations such as clearing, grubbing, stripping, pioneering, draining, grading, and excavating.

These operations are accomplished primarily with the use of heavy construction equipment.

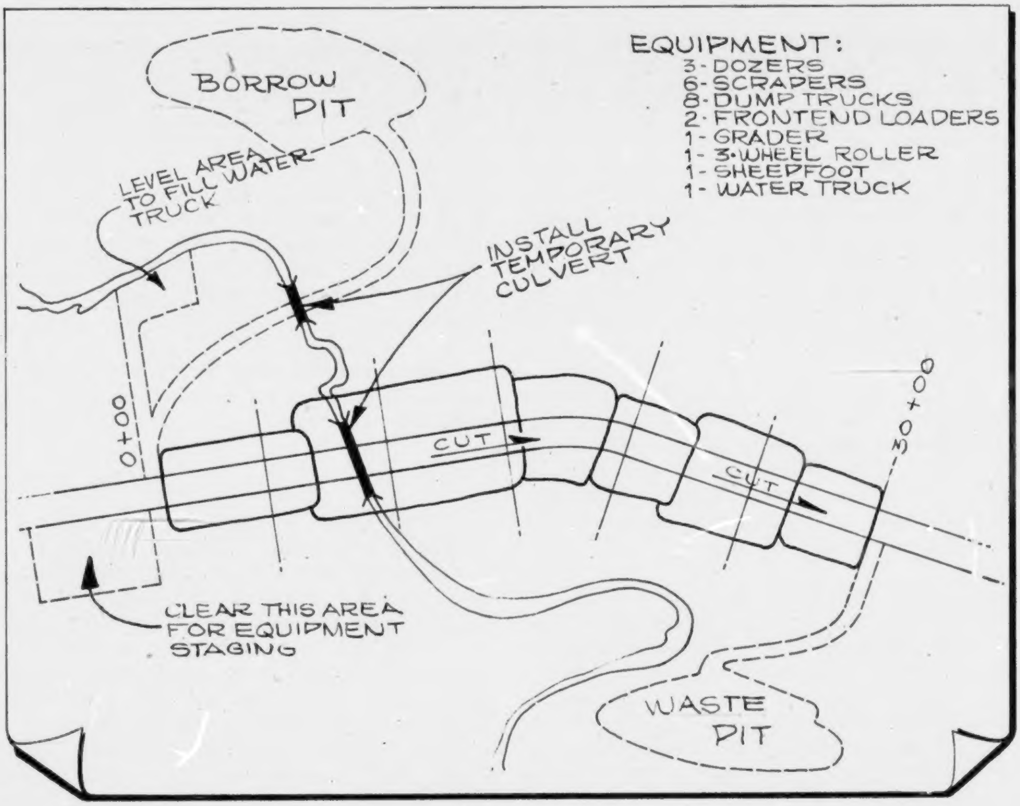


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Figure 8-3. — Plan overlay sketch emphasizing temporary road and culverts.

Hand or power felling equipment, explosives, and fire are used where they are applicable to facilitate the completion of these operations. The conditions to consider in determining the methods to be used in earthwork operations are: the acreage to be cleared, the type and density of vegetation, the physical features of the land, expected weather conditions, and the time available for completion of the job. For best results a combination of various methods is used in a sequence of operations; this can be accomplished by utilizing each method where it is most suitable and effective.

Clearing

CLEARING is a construction operation consisting of clearing a designated area of trees, timber, brush, other vegetation, and rubbish; removing surface boulders and other material embedded in the ground; and disposing of all material cleared. In theaters of operations, land clearing also includes the removal and disposal of mines, boobytraps, unexploded bombs, and land and underwater military obstacles.

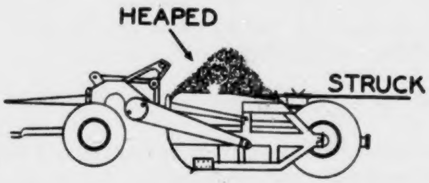

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Figure 8-4. — Heaped load.

Climate, terrain, and soil conditions will affect clearing procedures and operations. Clearing usually is accomplished by pushing uprooted trees, stumps, and brush in both directions from the center of the area to be cleared. Clearing should be done so that debris (spoil material) is placed in a designated spot with only ONE handling. In clearing landing strips, for example, it is generally necessary to dispose of material along each side of the strip outside the construction site. If the site is located where burning may be done, the haul distance can be reduced by piling brush, stumps, and trees on the site and burning them.

Figure 8-5 shows the proper steps used to remove large trees. Note in step 4 that a ramp is used to obtain greater blade height and leverage on the tree. Very large trees may require blasting to break the roots. As large trees are pushed away, they will carry with them smaller trees, brush, and grass.

Trees should be felled in a predetermined order to prevent them from lodging against one another and thus causing a difficult removal problem. Felling and removing trees with a bulldozer requires precautions to avoid injury to persons and damage to equipment. You should take special care in dozing dead trees. Although their weakened roots allow easier removal than green trees, dead trees are more dangerous to remove. Dead limbs may snap off and strike you, resulting in severe injury. A large tree could fall with a force strong enough to damage your tractor. There must be a "headache" rack on the dozer to protect you while removing trees.

Uprooting trees near pavements and structures is a very tedious job. To prevent structural damage, first dig trenches around the trees and chop the roots away with hand implements. Uprooting may be easier if the trees are killed some time before the uprooting operation by girdling (cutting deeply through the outer bark), poisoning, or burning.

Grubbing

GRUBBING consists of uprooting and removing roots and stumps. In grubbing, stumps which are difficult or impossible to pull out, even with winches, should be burned or blasted. Your chief will decide which method is to be used. If the stumps are to be removed by blasting, a qualified blaster will be called upon to do the job. If they are to be burned, you may be assigned the task. Green stumps require continuous application of heat before they catch fire. Check with your chief about safety measures that will keep the fire from getting out of control if you have to do any stump burning. Remember that it may take as long as 3 or 4 days for a stump to burn out, and a check on the burning must be kept during this period. If a project has a high priority, stumps will probably be blasted rather than burned to save time.

When stumps have been removed, refill the holes, and level the area to prevent the accumulation of water.

Stripping

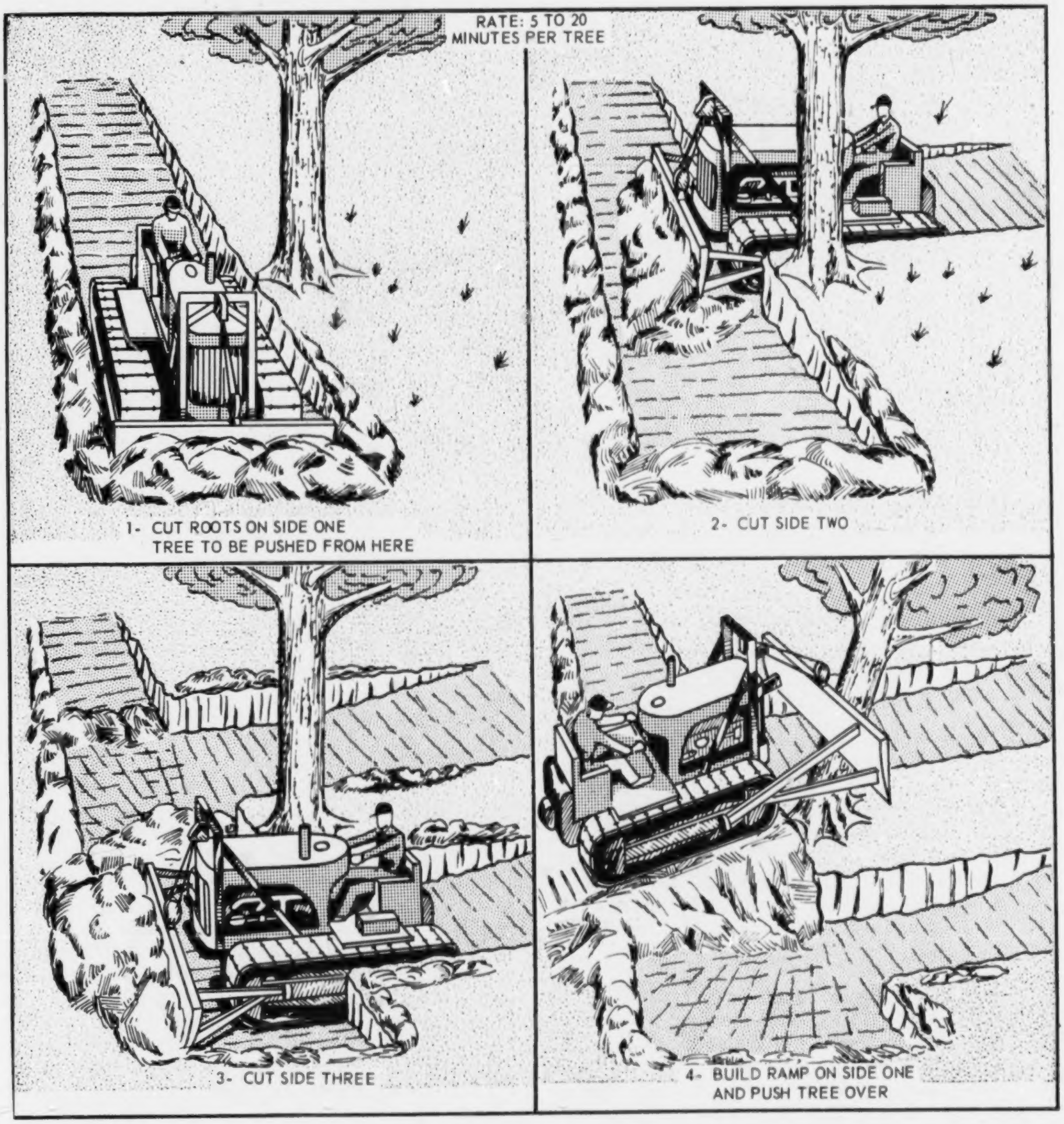
STRIPPING consists of removing and disposing of objectionable topsoil and sod.

Stripping may either follow or be done together with clearing and grubbing. Actual earthmoving begins with stripping; surface soil and rocks are removed from the area to be excavated. Deeply embedded rocks and large boulders may have to be blasted before they can be removed. The material removed by stripping is called SPOIL. Unless otherwise directed, you should dump spoil along the area to be excavated, within range of the earthmoving equipment. If the spoil will not be put to use, such as turfing or finishing the shoulder of a road or runway, it should be wasted along the edges of the project taking care not to disturb necessary drainage. (See fig. 8-6.)

Equipment commonly used in stripping includes the dozer, scraper, and motor grader. The DOZER is used, as mentioned earlier, in removing trees.

Dozers will handle all short-haul excavations (up to 300 feet). For long-haul excavations (over 300 feet), crawler or rubber-tired tractors and scrapers should be used. A scraper may be used also on fine soils where shallow stripping is desired.

A MOTOR GRADER is used mainly for shaping and finishing a stripped surface. It is adaptable also for ditching, for sidecasting, and for sloping banks. If digging operations are to be performed together with stripping, some graders can be adapted for digging by installing a front dozer


RATE: 5 TO 20 MINUTES PER TREE
1- CUT ROOTS ON SIDE ONE
TREE TO BE PUSHED FROM HERE
2- CUT SIDE TWO
3- CUT SIDE THREE
4- BUILD RAMP ON SIDE ONE
AND PUSH TREE OVER

115.58

Figure 8-5. — Steps in removing large trees with bulldozer.

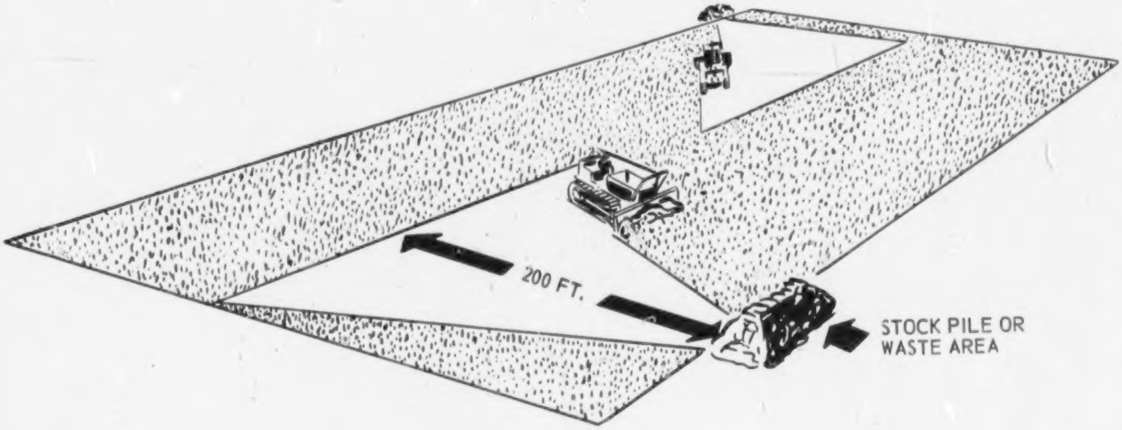


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Figure 8-6. —Stripping.

blade. (Grading and related operations will be described in connection with drainage systems.)

Pioneering

PIONEERING means the first working over of an area that is overgrown or rough, and making that area accessible for the equipment to be used in whatever work is required.

In pioneering the operations of clearing stripping, grading, and drainage are all done practically at the same time rather than performed as separate operations. A dozer starts out along a predetermined route and leaves a road behind it. This may be a haul road, on which trucks and equipment will move in later operations. In some mountain road pioneering, a power shovel is used to dig and cast material over the side of the mountain.

Suppose you, as a dozer operator, are given the job of cutting a road on the side of a mountain to be used for access to a proposed airstrip site, or to reach a mountain stream which is to be developed into a water supply system. Where should you start and how should you proceed? The route your mountain road is to follow will be staked out by a survey party. You should start your road at the highest point possible, making use of the force of gravity on the tractor, as indicated in view A, figure 8-7, and then proceed as shown in view B.

In clearing on sidehill cuts, brush and trees should be cast far enough to the side of the road so that they will not be covered with the earth. It is even better if you can cast them over the edge using an angledozer blade, when the road is cut. When you are cutting the road, do not watch the grade stake immediately ahead of you, or you will find yourself below grade. Instead, watch the third or fourth stake down. It is better to be above grade and come back and cut down to grade than it is to be below grade and have to come back and fill. A sidehill cut is one of the places where it is more efficient to move part of a load rather than attempting to take a full load. Take only part of a load and move it out over the bank. If you take a full load, you will soon find you have a bank of earth in front, and you are working uphill. Another reason for taking only part of a load is that it is easier to control the tractor and cast over the bank than with a full load. A wide track, close coupled dozer with a blade that can be tilted to cut low on the uphill side is most efficient. An angling blade, set with the uphill side low and angled to cast down the hill, is useful, particularly in light soils and shallow cuts.

Drainage

DRAINAGE involves the construction of facilities needed to drain excess surface and subsurface water from the construction site.

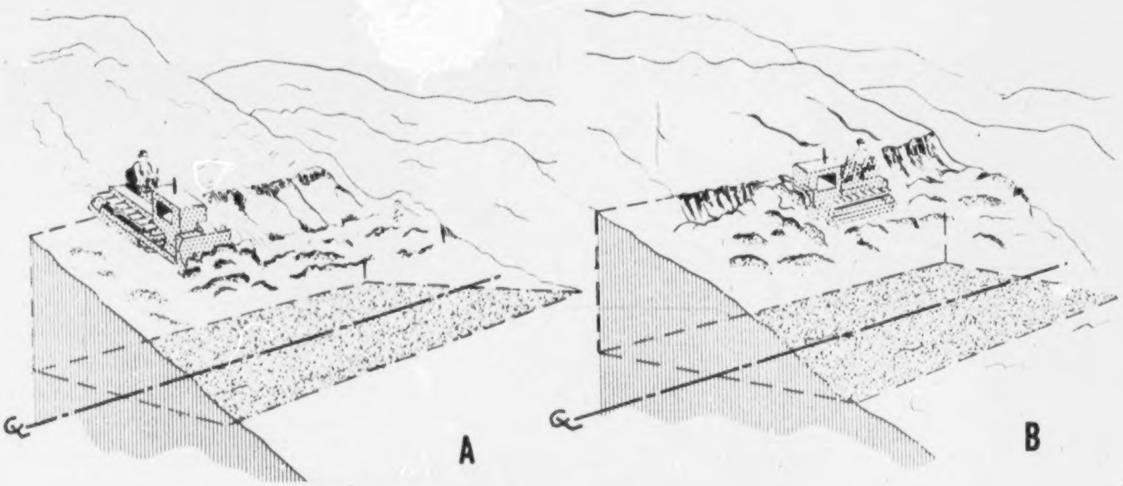

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Figure 8-7.—Start your road right.

Properly designed and constructed drainage systems are one of the most important parts of a construction project. Without proper drainage, rainwater and water running off surrounding ground could turn the area into a lake. It is also necessary to drain off surface water which would soak down and wet the subgrade.

To facilitate drainage, diversion ditches are excavated to conduct all surface water into natural channels or outfall ditches. Outfall ditches are constructed to drain low or boggy spots. At the point at the end of the system where the accumulated runoff discharges into the disposal point, the runoff is technically known as DISCHARGE. The discharge point in the system is called the OUTFALL. This preliminary work is done at the same time the area is cleared and grubbed.

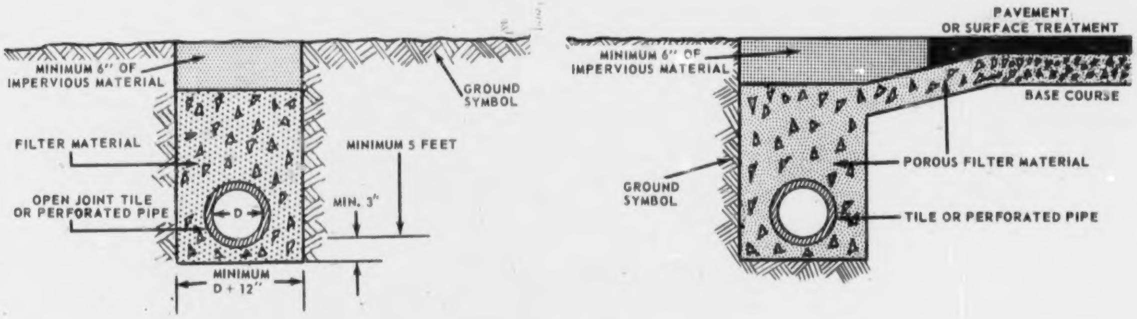
The finished drainage system will usually consist of ground slopes, ditches, culverts, gutters, storm drains, and underground water drains. Open channels are used to intercept or control surface water. These will be dug by bulldozers, scrapers, backhoes, or motor graders—depending on circumstances. When it is necessary to drain water across a construction site culverts are constructed. Subdrains (to drain ground water) are usually excavated with ditches, or backhoes. The drains used are French drains (perforated or open-joint tile pipes). Figure 8-8 shows typical French and covered drains used to drain ground water.

Run off water, from rain or melted snow, is removed from the area by constructing an adequate transverse slope or crown. This runoff is collected in ditches and drained into the nearest natural-drainage channel. Drainage for construction sites can be provided by building the ends of the site sloping towards the middle, or sloping from one end to the other. These types of construction are shown in figures 8-9 and 8-10.

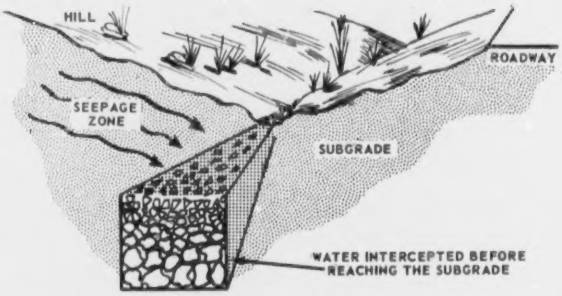
Grading and Excavating

GRADING and EXCAVATING involves cutting the high spots to grade and filling in the low spots. In cutting down the high spots, enough suitable fill material may be removed to fill the low spots. However, it may be necessary to develop other sources of fill material.

If it is necessary to borrow fill material, usually a power shovel is used to dig up the material. Dump trucks, dump wagons, or motorized scrapers are used to haul the material to the fill spots. If the site is on hard and rocky terrain, it will be necessary to loosen and break the soil by using a ripper (discussed in ch. 9).



COVERED DRAINS

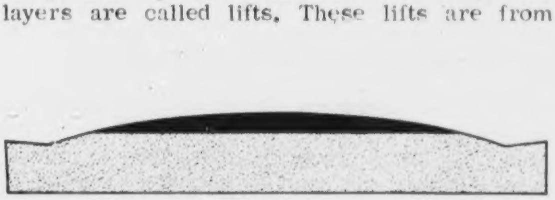


FRENCH DRAINS

115.63

Figure 8-8. — Typical sections of covered and French drains.

Before fill material can be placed in low spots, a suitable foundation must be prepared. It may be necessary to excavate material of low-bearing capacity before placing the fill. When it is necessary to place fill on the side of a hill, suitable benches are cut before the fill is placed. Drainage must be provided under the fill. In general, all fills are built up in compacted layers. In construction work, these layers are called lifts. These lifts are from 3 tenths to 1 foot high, depending upon the compaction necessary, compaction equipment available, and the material used for the fill. In constructing a fill, each lift is spread either by dozer or scraper and then compacted. The fill material must have the right amount of moisture, referred to as "optimum moisture content," to obtain maximum compaction; therefore, at times it is necessary to wet the fill before it is compacted. Compaction may be obtained by using rollers such as pneumatic, tandem, oscillating, or vibratory types.



115.64

Figure 8-9.—Cross section of land strip showing desirable ditch construction.

After all preliminary cutting and filling have been completed, the job is brought to final grade by motor graders.

SOILS

Since you are going to be working with earth and earthmoving equipment, you should know

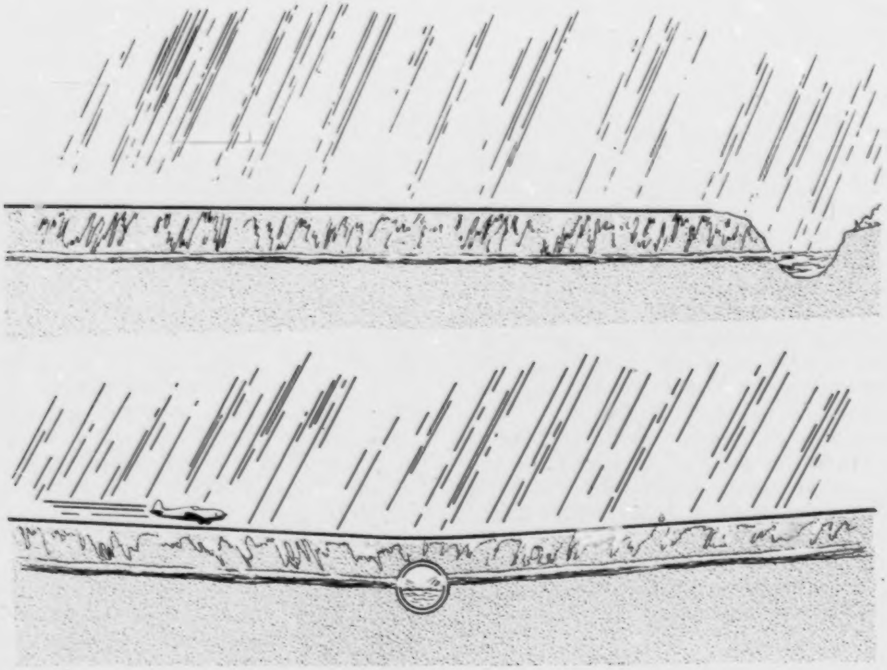


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Figure 8-10. — Longitudinal drainage of runways.

something about the material you are to handle. The study of earth or soil is termed SOIL ENGINEERING or SOIL MECHANICS. It is a complicated subject, but for your purposes, it is not necessary to go into the subject in great detail.

For identification and classification purposes, all soil can be grouped into two principal types: mineral and organic. Each type has distinctive properties which can be identified in the field. Each type of soil also has distinct engineering characteristics. Let's take a look at the soils with which you will work.

MINERAL SOILS

The identification and classification of mineral soils are discussed below. The soils can be grouped into the following types: gravel, sand, silt, and clay.

Gravel

You are probably familiar with GRAVEL. In soil terminology, any bulky mineral grain larger than about one-fourth inch is classed as gravel. Gravel is made up of rocks of various sizes. As a rule, they are worn smooth by water action. Next to solid bedrock, well-graded and compacted gravel with enough fine material to fill the voids between the gravel is the most stable and natural foundation material. It is a desirable material for base and surface courses for airfields and roads, since it is easy to drain, easy to compact, not affected greatly by moisture, and not subject to frost actions.

Sand

Mineral grains ranging in size from about 0.10 millimeter (mm) to 2 millimeters in diameter are classed as SAND. (There are about 25 mm in an inch.) Well-graded angular sand is a desirable foundation material if it can be confined. It is relatively easy to compact, easy to drain, little affected by moisture, and ordinarily not affected by frost actions. If sand is uniformly very fine, it approaches silt and has many undesirable characteristics. Confined sand provides an excellent subgrade, and for this reason, it works well under metal landing mats.

Silt

Silt consists of mineral grains much finer than sand. These grains are between 0.002 mm and .05 mm in diameter. Silt is sometimes termed "rock flour." It is not plastic and does not hold together when dry. It can be distinguished from fine sand, because it feels smooth—not gritty to the touch. Silt may also be identified by making a small mud pie of it and shaking it in your hand. If the sample is silt, water will come to the surface, causing it to look glossy and soft. Squeezing the sample causes the water to disappear. Due to their instability, slight disturbances in the presence of water (such as traffic vibrations transmitted to a wet silt subgrade) may cause them to become soft or to change into a quicksand condition. When ground water or seepage is present , silts are subject to ice accumulation and consequent heaving when exposed to front actions. Silts are difticult to compact and difficult to drain.

Clay

CLAY consists of particles .002 mm in diameter or smaller. Clays, when they have the proper moisture content, are sticky. This is their most important characteristic. If a piece of clay is kneaded with enough water to make it moist, it can be squeezed through the fingers to form a ribbon that does not break under its own weight. This test may be used to differentiate clay from silt. Clay is difficult to drain when there is ground water. It can be compacted when the moisture content is right. It varies in consistency from slippery to sticky, depending on moisture content. Hard clay is difficult to excavate and may require the use of a ripper.

ORGANIC SOILS

ORGANIC SOILS are of two types: peat soils, consisting largely of partly decomposed vegetation, and finely-grained mineral sediments containing various amounts of finely-divided vegetable matter. Peaty soils can be identified by visual inspection. In organic clays and silts, the organic matter is so finely divided that it cannot be detected easily. You may be able to identify organic material by the smell. Peaty and organic soils are unsatisfactory subgrades. In general, they should be removed.

Soil Mixtures

Soils seldom exist naturally separated as gravel, sand, silt, clay, or organic material, but are found as mixtures with varying proportions of the principal types. Each type of soil contributes its characteristics to the mixture. Some combinations make excellent subgrade, base, or surfacing materials. An excellent example is a mixture of the right proportions of gravel, sand, silt, and clay. Another example is LOAM, a soft mixture of sand, silt, and clay. Such mixtures are sometimes found in nature. However, it is frequently necessary to combine separate soils by mixing to produce a satisfactory combination. Identification of combined soils depends upon recognition of the individual and predominant components.

Most roads and airstrips are surfaced with concrete or some bituminous material. Certain other materials, however, can be used to surface roads and airstrips. These materials include coral, caliche, decomposed granite, and laterite. At an advanced base any of these materials may be used because of the importance of using materials that are readily available. SEABEES often use coral and laterite for construction purposes.

Coral, caliche, decomposed granite, and laterite ordinarily do not require blasting. These materials can usually be loosened with rippers and bulldozers and can be picked up with tractor-drawn scrapers, or they can be loaded into trucks with power shovels.

Coral

Coral consists of the skeletons of tiny sea animals which have solidified into a stony mass. It varies in color from pure white to reddish.

Coral is found in the banks and the hills of Pacific and Caribbean islands. It may be excavated with a power shovel, or it may be dredged from the ocean floor. It is excellent subgrade and surfacing material, since it is easily drained. Live coral has natural cementing properties. Hard dense coral may be crushed and mixed with bituminous binders for blacktop finishing of roads and airstrips.

Caliche

Caliche is a hard, cemented soil layer located on or near the earth's surface. It does not soften when wet. Caliche is usually found in semiarid regions like Arizona. A reddish brown material, it may be fine in texture, or it may resemble coarse grains of sand cemented together. Larger stones may be lodged in caliche. It is sometimes found on the building site, or it may be excavated from pits and banks. Like coral, caliche is easily compacted, drained, and has natural cementing properties. Caliche is very useful as a natural subgrade and surfacing material.

Decomposed Granite

Decomposed granite, as its name implies, is granite that has become soft from long weathering. In color, it varies from reddish brown to black. Like caliche, it may be found in place on some jobs. Otherwise, it is excavated from pits and banks. Decomposed granite has the same compacting and draining characteristics as caliche and coral. Hence, it also provides a good natural subgrade and surfacing material. You may hear someone referring to "D.G." in a conversation about road or airfield construction. He is talking about decomposed granite.

Laterite

In general, the term laterite usually refers to a material in the profile of a tropical soil. The color of laterite is mainly reddish, varying from yellow to brown. Unfortunately, there are numerous reddish soils in Southeast Asia: clayey silts; the old marine sands; the weathered products of may granitic rocks, etc. The tendency is to call any of these materials "laterite," and this has led to recurring construction headaches. Laterite in Southeast Asia has rarely been found in a completely "soft" or doughy state which upon short time exposure to the drying effects of the atmosphere, "hardens irreversibly" to a rock-like substance.

Laterite is most commonly found in grey sandy soil regions, such as the Mekong Terrace in Vietnam. It is suitable for most road construction and can be used for medium airfields. Laterite has also been used, to some extent, as aggregate for low-grade concrete and when mixed with cement, as soil-cement bricks. Laterite usually occurs as a massive deposit, ranging in thickness from less than a foot to over 30 feet.

The laterites tested are well graded and have sufficient fines to provide a binder to prevent excessive loosening of the surface under wheel loads.

Laterites are used as a surface course material for many of the expedient roads and airfields in Southeast Asia. A surface treatment of peneprime, oil, or some other asphaltic compound is commonly used as a dust preventive and waterproof coating.

Laterite has sufficient strength when properly compacted and drained to serve as a combination surface and base course for airfields. If the subgrade is well drained, a relatively thin layer of laterite (6 to 12 inches) will usually suffice. By increasing the thickness of the laterite, the likelihood of saturation and softening of the base course during the wet season is decreased. When operating equipment over laterite road surfaces affected by moisture or rain, traction loss is greatly increased. Make sure you adjust your driving procedures to meet these changing conditions.

Learn to recognize these natural road building materials; they are hard to find. If you cut into a bank of coral, caliche, decomposed granite, or laterite, your discovery may mean valuable savings to the Navy.

ESTIMATING EARTHWORK

Estimating is the act of determining the size and kind of work to be performed and determining the quantities of work elements, materials, labor, and equipment needed to perform this work.

In the following section, various factors such as earth compaction, equipment capacity and output, volume changes and estimating of materials used in earthwork operations are given so that you may understand and relate these factors to proposed earthwork projects.

COMPACTION

Compaction, as used in earthwork operations, means pressing together soil particles to form a consolidated mass with increased stability. Compaction helps the soil to shed rainwater and also makes the soil more resistant to soaking up moisture from below. Coral and caliche, as well as soft soils, may be compacted.

Compaction can be accomplished by rollers, pneumatic tire units, and similar equipment, to obtain a soil surface hard and firm enough to support loads without settling or buckling.

There are no uniform procedures for compacting earth, because soil types, operating conditions, and equipment available vary from area to area. Still, there are a few principles of compaction that can be applied generally: soil particles must fit together tightly; the soil must have enough moisture content to form into a smooth surface; and the earth must be placed in layers thin enough to permit excess air and water to be expelled easily.

While you need not know the tests for adequate compaction, you must learn to recognize poor surfaces. Soggy surfaces indicate the presence of excess moisture, while uneven, lumpy surfaces indicate too little moisture.

CAPACITY AND OUTPUT

Most types of earthmoving equipment have a bucket, bowl, or body, which is loaded, hauled, offloaded, and returned to the loading point. The carrying capacity of buckets, bodies, and bowls are rated in loose yards by the manufacturer. The bowl capacity of a TD-20 B International, for example, is rated at 3.2 loose cubic yards. For this rating, it is assumed that the dozer is working on level ground and that the earth being worked is an average mixture of loam.

The capacity of a scraper is also expressed in loose cubic yards, but this capacity may be either struck or heaped. Struck capacity is the volume of earth a scraper carries when earth is leveled to the top of the bowl. Heaped capacity is the volume carried when earth is heaped to the maximum in the center of the bowl. In earthmoving operations, scrapers are normally heaped to capacity.

Power shovels are rated by the number of loose cubic yards of earth the dipper holds when filled level. This amount is called the LOOSE STRUCK CAPACITY.

Dump trucks are normally rated in struck capacity; heaped capacity must be estimated. Dump trailers may be rated in either struck or heaped capacity. Body capacity of trucks and trailers is usually given in cubic yards, but may be expressed in tons.

The capacity of most equipment is usually noted on a plate somewhere on the equipment. If you are not able to locate this information, consult your chief.

VOLUME CHANGES

When material is dug from its natural terrain position, it increases in volume. This increase is called SWELL. Digging loosens the materials and increases the size of the voids between particles, and this results in increased volume. Undisturbed material is measured in IN-PLACE cubic yards. Material loosened by handling is measured in LOOSE cubic yards. As previously mentioned, the carrying capacity of earthmoving equipment is measured in loose cubic yards. In-place cubic yards must be converted to loose yards to determine the amount of equipment required to handle the material. Decrease in volume when material is compacted is called SHRINKAGE. The volume of compacted material is measured as COMPACTED cubic yards.

Volume changes are illustrated in table 8-1, which gives you conversion factors for volume changes of various types of soils.

In using table 8-1, always work from the present condition of the soil and convert to the desired condition. Let's take an example and point out the steps to be followed.

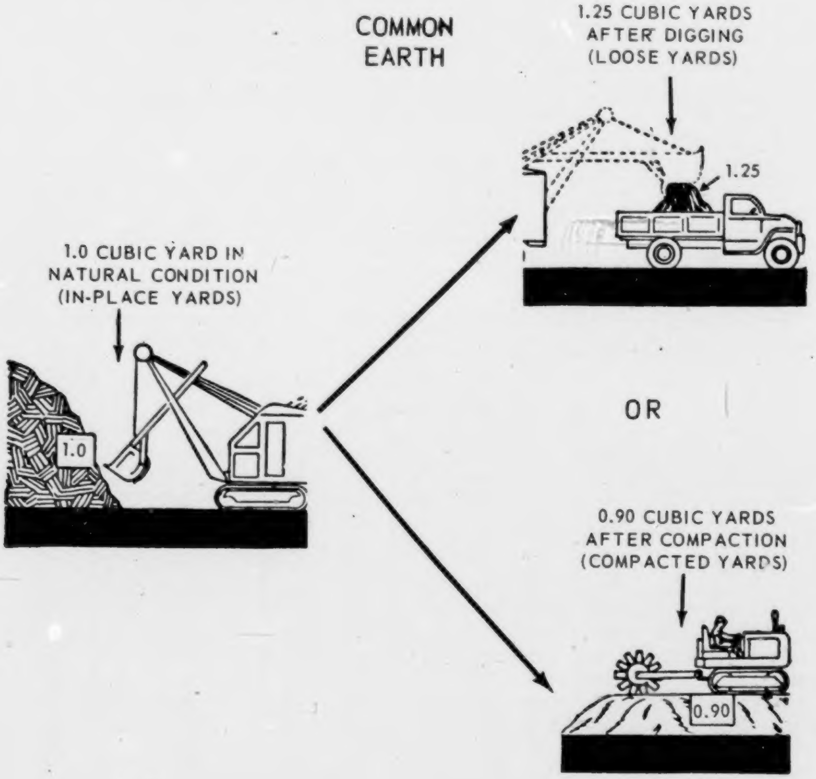
From a set of blueprints it is determined that 250 cubic yards of common earth are needed for fills. As fills are considered compacted, and using this condition to start with, step (1) would be as follows:

250	cubic yards of fill
x 1.11	factor from table 8-1 for compacted to in-place.
= 277.50	cubic yards of in-place material to be dug.

In-place cubic yards are converted to loose cubic yards to determine the amount of earthmoving equipment required to handle the material. To find the number of cubic yards to be hauled, step (2) would be as follows:

277.50	cubic yards of in-place material.
x 1.25	factor from table 8-1 for in-place to loose.
= 346.87	or 347 cubic loose yards to be hauled.

Table 8-1. — Adjusting Volumes


COMMON EARTH
1.25 CUBIC YARDS AFTER DIGGING (LOOSE YARDS)
1.25
1.0 CUBIC YARD IN NATURAL CONDITION (IN-PLACE YARDS)
1.0
OR
0.90 CUBIC YARDS AFTER COMPACTION (COMPACTED YARDS)
0.90

SOIL TYPE	PRESENT SOIL CONDITION	CONVERTED TO:		
		IN PLACE	LOOSE	COMPACTED
SAND	IN PLACE	1.00	1.11	0.95
	LOOSE	0.90	1.00	0.86
	COMPACTED	1.05	1.17	1.00
COMMON EARTH	IN PLACE	1.00	1.25	0.90
	LOOSE	0.80	1.00	0.72
	COMPACTED	1.11	1.39	1.00
CLAY	IN PLACE	1.00	1.43	0.90
	LOOSE	0.70	1.00	0.63
	COMPACTED	1.11	1.59	1.00
ROCK	IN PLACE	1.00	1.30-2.00	1.25-1.50
	LOOSE	0.50-0.77	1.00	0.75-0.96
	COMPACTED	0.67-0.80	1.04-1.33	1.00

115.241

Table 8-2.—Hasty Estimates of Earthwork Volumes

CONTENTS: THIS TABLE SHOWS THE NUMBER OF CUBIC YARDS OF EARTHWORK THERE ARE IN A 100' LONG SECTION OF CUT OR FILL HAVING A KNOWN AVERAGE DEPTH. TO USE THIS TABLE YOU MUST KNOW:

1. A. CUT SECTION – THE WIDTH OF THE BASE OF THE CUT, INCLUDING DITCHES.
   B. FILL SECTION – THE WIDTH OF THE TOP OF THE FILL.
2. THE AVERAGE AMOUNT OF CUT OR FILL.
3. THE SLOPE RATIO. COLUMN 2 GIVES THE CORRECT AMOUNT OF EARTHWORK WHEN THE SIDE SLOPES ARE 1:1. WHEN THE SLOPE RATIO IS OTHER THAN 1:1, AND ADJUSTMENT MUST BE MADE *(See Column 4).*

NOTE: THE FINAL ANSWER OBTAINED FROM THE TABLE IS FOR A SECTION 100' LONG. IF THE ACTUAL LENGTH OF THE CUT OR FILL IS NOT 100', AN AJUSTMENT MUST BE MADE. *(For an 85' Section, Multiply by .85; for a 50' Section, Multiply by .50, etc.)*

COLUMN 1	COLUMN 2										COLUMN 3	COLUMN 4	
AVERAGE AMOUNT OF CUT OR FILL	WIDTH OF THE BASE OF THE CUT *(Or/Top of the Fill):*										FOR EACH ADDITIONAL FOOT OF WIDTH, ADD:	IF THE SLOPE IS 1½:1, ADD:	IF THE SLOPE IS 2:1, ADD:
	26'	28'	30'	32'	34'	36'	38'	40'	42'	44'			
1'	100	107	115	122	130	137	144	152	159	167	3.5	2	4
2'	208	222	237	252	267	281	296	311	326	341	7.5	7	15
3'	323	344	367	389	411	433	455	478	500	522	11.0	16	33
4'	444	474	504	533	563	593	622	652	681	711	15.0	30	59
5'	574	611	648	685	722	759	796	833	870	907	18.5	46	93
6'	710	756	800	844	889	933	978	1022	1066	1111	22.0	67	133
7'	855	907	959	1011	1063	1115	1167	1219	1271	1323	26.0	91	181
8'	1010	1067	1126	1185	1245	1304	1363	1433	1482	1541	29.5	118	237
9'	1167	1233	1300	1367	1433	1500	1567	1634	1700	1767	33.5	150	300
10'	1333	1407	1482	1556	1630	1704	1778	1852	1926	2000	37.0	185	370
11'	1507	1589	1670	1752	1833	1915	1996	2078	2159	2241	41.0	224	448
12'	1688	1778	1867	1956	2045	2133	2222	2311	2400	2489	44.5	267	534
13'	1877	1974	2070	2167	2263	2359	2456	2552	2648	2745	48.0	313	626
14'	2074	2178	2282	2385	2489	2593	2696	2800	2904	3007	52.0	363	725
15'	2268	2389	2500	2611	2722	2833	2944	3056	3167	3278	55.5	426	852

115.242

The output of equipment in loose cubic yards must be converted to compacted cubic yards to determine the final volume of fill. Now, the amount of compacted cubic yards to fill realized from the haul would be determined in step (3) as follows:

346.87	cubic yards to be hauled.
x .72	factor from table 8-1 for loose to compacted.
= 249.74	or 250 cubic yards of fill needed.

HASTY VOLUME ESTIMATES

Where cuts or fills are deep, side slopes exists, or when the job is large, yardage should be carefully calculated. When time is a vital element and the type of construction low, earthwork quantities are estimated roughly.

An example of this would be where a road is built over flat or slightly rolling ground, and the excavation for ditches is merely thrown up on the roadbed to form a crown. Consequently, hasty estimates for the average cut and fill as shown in table 8-2 would be utilized.

Having only the centerline profile plotted and grade established, earthwork can be estimated. The average depth of cut or height of fill between 100-foot stations is estimated and the volume of material is then read from table 8-2. Best results are obtained for through cuts and fills in fairly level terrain. Values in table 8-2 are "in place" volumes only. The following example illustrates the use of table 8-2:

(1) Required: The number of cubic yards per 100 feet of cut, 30 feet wide at the base, 1-1/2 to 1 side slopes, and an average depth of 5 feet.

(2) Looking at the table at 5 feet in column 1 and continuing horizontally to column 2, the value for a 30-foot cut is found to be 648 cubic yards. Continuing horizontally, column 4 indicates that 46 cubic yards must be added when sides slopes are 1-1/2 to 1.

(3) The answer is as follows: 648+46=694 cubic yards of cut for every 100 feet of length.

Many dimensions in field measurements and project plans are in feet, so they are multiplied together to obtain bulk, and the results are in cubic feet.

Most earthwork and earthmoving is computed in cubic yards. A cubic yard is a cube 3 feet long, 3 feet wide, and 3 feet high (3' x 3' x 3'), which equals 27 cubic feet. Therefore, to get cubic yards, divide the results in cubic feet by 27.

CHECKING AND ESTABLISHING GRADE ELEVATIONS

The first major step in road construction is usually "rough grading," which is the earthmoving required to bring existing grade up to, or down to, the approximate grade required. In normal earthwork operations the EA will place adequate road boundary markers as a guide for the EOs for clearing, grubbing, and stripping. After the proposed road area has been cleared, grubbed, and stripped by the Equipment Operators, the EA crew will place various stakes for road alignment, cut or fill, and shoulder slope. After the road has been shaped to approximate grade, the EA crew will replace the stakes for final grading.

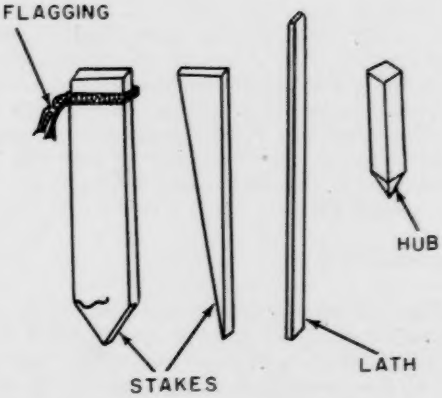
This section is intended to provide the EO with some basic surveying, that is, reading and interpreting stakes, checking grade, and measuring distances. This information will help the EO understand and efficiently work with stakes that have been placed by the EA crew. And, in the event that the EA crew is not available, the EO should be able to perform the surveying procedures that will be explained here.

STAKES

The term "stake" is used in a general sense to indicate any wooden lath, stake or hub used in laying out construction projects and their boundaries. Hub stakes are 2" x 2" x approximately 12" and are used primarily for well defined Surveyors' reference points, with red and blue tops used in finished grade work. Stakes will vary in shape and size according to their use and materials available for their manufacture. Types of stakes are shown in figure 8-11. Stakes range in size from the ordinary rough plaster's lath to 1" x 2" or 3" cross-section lumber with their lengths varying from 18" to 48".

All reference hubs, markers, and bench marks established by the Engineering Aids for project control or alignment are protected by GUARD stakes. They guard nothing but are used merely as a means of relocating the point needed. There is usually some color of "bunting" or "flagging" (a narrow strip of cloth or plastic) tied around the top of the stake. Station identification is placed on the front of the stake and any other pertinent data is placed on the back.

Construction stakes are the guides and reference markers for earthwork operations to show cuts, fills, drainage, alignment, and boundaries of the construction area. The number of stakes and the information contained on the stake will vary in accordance with the project as to whether it is temporary or permanent. Stakes are usually placed by a 3 to 5 man survey party using transit, level, chain, rod, and range poles. In some situations, the survey crew will only establish grades on the centerline stakes, while



115.239

Figure 8-11. — Types of stakes.

edge-of-road and slope stakes are set by construction foremen and helpers. Alignment, shoulder, and slope stakes should be of 1" x 2" or 3" in cross-section, smooth on four sides, and about 2 feet in length. Actual grade desired is indicated by a reference mark called a "crowfoot" and numbers to show the amount of cut or fill. Finish grade stakes are usually 2" x 2" hubs about 6 to 12 inches in length. They are driven into the ground so that the top of the stake is on the actual grade desired. The tops of the finish grade stakes are colored "blue" for finish grade and "red" to indicate finish sub-grade; hence the terms "blue tops" and "red tops".

So that stakes will be properly interpreted by the construction crew, they are marked with the following information in both road and airfield construction:

1. The stationing or location of any part of the road, runway, or taxiway relative to a starting point or reference.
2. The amount of cut and fill from the existing ground surface or reference mark on the stake at that point, or the shoulder or ditch line when off-set stakes are used.
3. The distance from the centerline to the stake location.

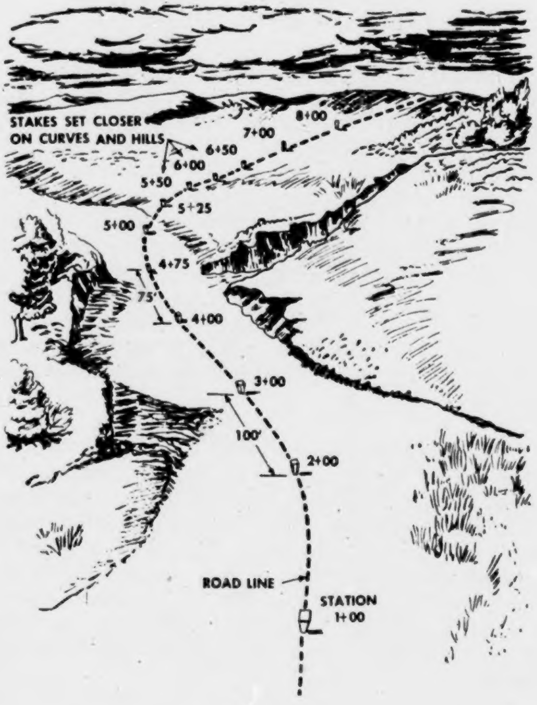
Line Stakes

Line (or alignment) stakes mark the horizontal location of the earthwork to be completed and give the direction of the proposed construction. Line stakes must not be disturbed. Running over stakes or otherwise damaging the stake before they have served their purpose results in many hours of extra work for replacement and delay in the completion of the project. Rough alignment stakes are placed for ahead of the clearing crew and mark boundaries of the area to be cleared and grubbed. These stakes or markers are not of a control nature and their loss is expected.

Centerline Stakes

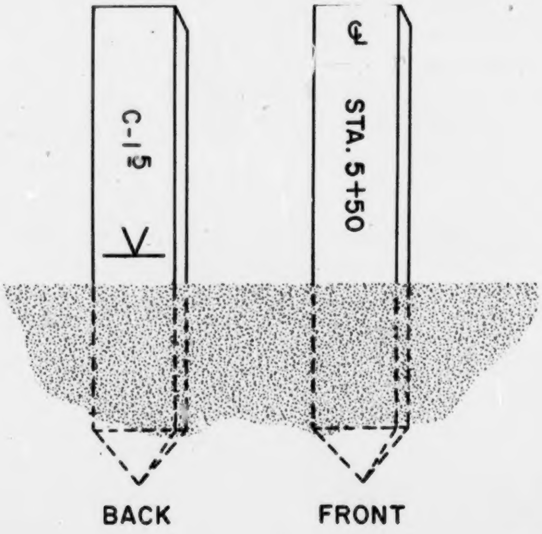
Final alignment stakes are sometimes placed as centerline stakes and you should learn to read the information contained on them. The front face of the centerline stake contains the station number which is the surveyor's method of locating the point's distance from a given or known location. The first station of reference would be marked 0 + 00 indicating 0 feet. The next station would normally be 100 feet farther and would be marked 1 + 00, and so forth. (See fig. 8-12.) A culvert to be located 1,857 feet from the beginning of the road or runway would be indicated by the centerline stake marked with station 18 + 57. Generally, the side of the stake marking the station faces the starting point and the mark is also included to indicate that the stake is on centerline.

The reverse side of the stake will indicate the cut and fill data. Cut is designated by the letter C, and fill by the letter F. Numerals follow the letter showing the proposed amount of cut or fill. The reference point for the cut or fill is marked on the stake by a crowfoot which also indicates whether a cut or fill is desired. Cuts and fills are given from the crowfoot to the nearest foot or half a foot, hence, 2^5 would indicate a cut or fill of 2.5 feet. C-1^5 followed by the crowfoot mark (V) would indicate a cut of 1.5 feet, and F-2° followed by a crowfoot shown as $\overline{\Lambda}$ would indicate a fill of 2 feet. Figures



115.67

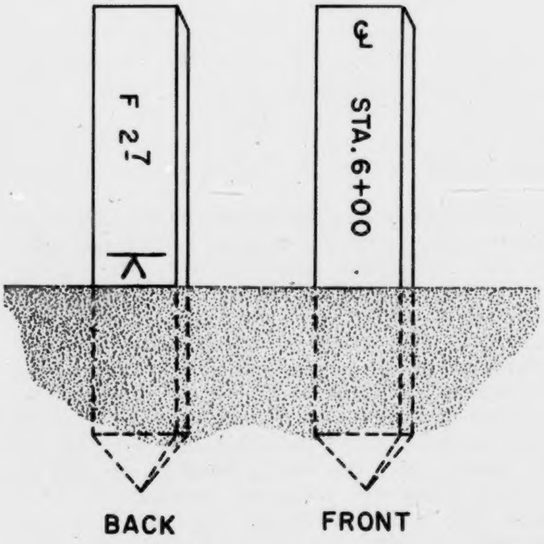
Figure 8-12. — Station markings.



29.79

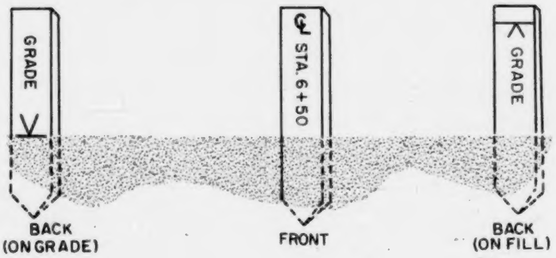
Figure 8-13.— Cut stake.

8-13, 8-14, and 8-15 show the proper method of marking a centerline stake with cut and fill data. The front of the stake in figure 8-14 shows the location of the station which is 600 feet from the reference point and the reverse side indicates a fill of 2.5 feet from the crowfoot. When the actual ground level is on the desired grade, the stake is marked with a crowfoot at ground level and the word GRADE or GR. is placed on the stake. If the three types of stakes shown in figure 8-13, 8-14, and 8-15 were consecutive stations on a construction project, the shape of the land to be graded might look like figure 8-16. Surveyors call this kind of picture a PROFILE.



29.80

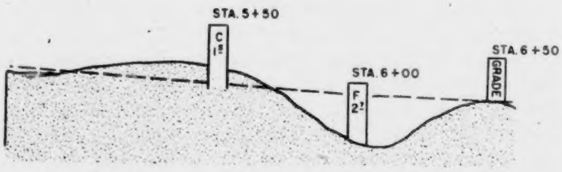
Figure 8-14.— Fill stake.



29.81

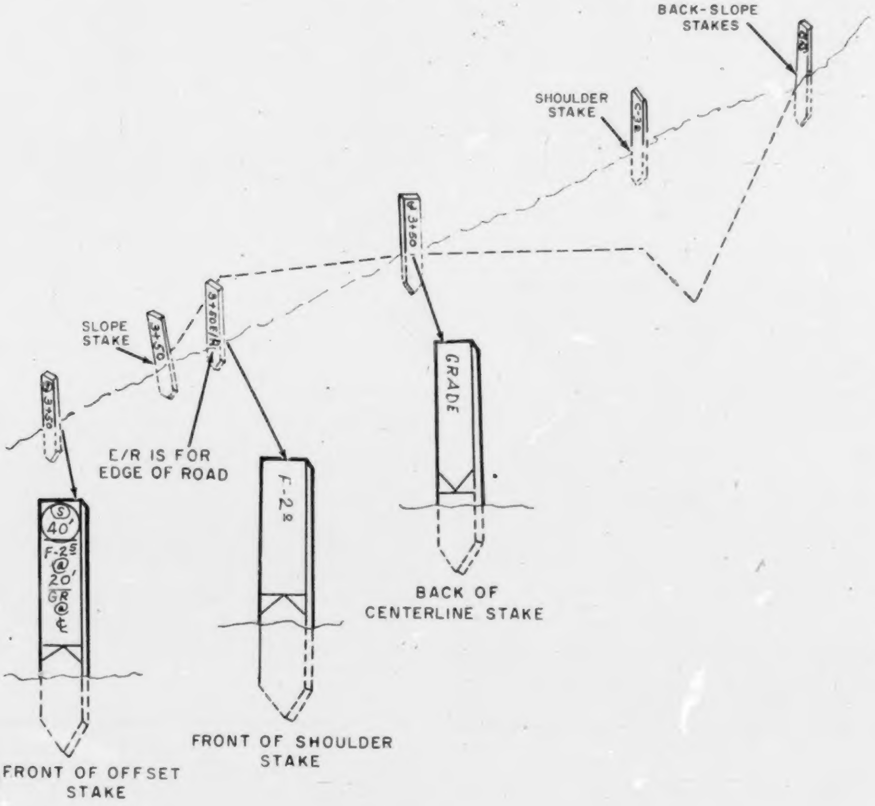
Figure 8-15.— Grade stakes.

Suppose the chief told you to take your dozer out to station 5 + 50 and grade to station 6 + 50, when you get to the starting point (station 5 + 50), get down off your dozer and look the situation over thoroughly. Remember that one step in doing an efficient job is to know what the finished job is to be. You will see that the grade stake at station 5 + 50 calls for a cut of 1.5 feet, the stake at station 6 + 00 calls for a fill of 2.5 feet, and the stake at station 6 + 50 tells you that the existing ground is on grade. You will plan accordingly, and use the material from your first station to fill at station 6 + 00. Before you start work, check the readings on



115.68

Figure 8-16.— A profile of land.



115.240

Figure 8-17.—Cross section view of stake placement.

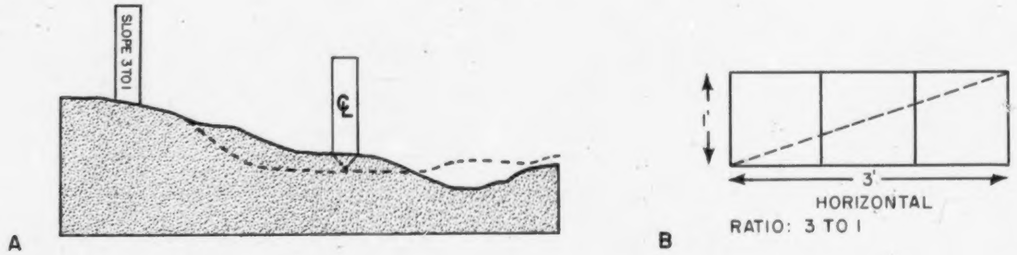
all of the stakes that you will work that day. Any excess fill material would be used in other fill areas or spoiled.

Shoulder Stakes

Shoulder stakes (sometimes called edge-of-road stakes) mark the outer edges of the shoulders. (See fig. 8-17.) They are set at right angles to the centerline on the shoulder line. Shoulder stakes are set with the broad side facing the centerline of the road. The same station numbers are placed on the back of the stake and the cut and fill data is marked on the face toward the centerline. The horizontal distance from the shoulder stake to the centerline may be placed underneath the cut or fill figure.

Slope Stakes

Slope stakes are set where the planned slope will intersect with the original ground and indicate the earthwork limits on both sides of the road or runway. Clearing and grubbing should extend outward about 6 feet beyond the slope stakes. Figure 8-18 shows the location and proper marking of a slope stake. Slopes are marked on the stake as a ratio of the horizontal distance to the vertical distance. Thus, in figure 8-18, slope stake A indicates that for every 3 feet away from the stake, the bank goes down 1 foot. When the slope is not indicated, the slope will be made to go from the bottom of the ditch or edge of the road to the base of the stake. A slope stake located in this manner is sometimes referred to as a "back-slope" stake.



115.70

Figure 8-18. — Slope stake and slope ratio.

In event that the back-slope stake is used in the manner of an "off-set" stake, the stake will indicate the amount of cut and the distance from the stake that would be the bottom of the cut as shown in figure 8-17.

Offset Stakes

In order to remove reference stakes from the actual working area, off-set stakes are placed to one side and marked in the same manner as the centerline station stakes. They will also indicate the distance that they are off-set from the centerline. Figure 8-17 shows the use of an off-set stake and how it is normally marked. Any reference to cut or fill which is placed on an off-set stake will also indicate at what distance from the stake it is desired. An off-set stake is indicated by marking a circle around the indicated distance. The information given on the offset stake shown in figure 8-17 indicates that it is off-set 40 feet from the centerline, fill 2.5 feet α (meaning located at) 20 feet from the off-set stake, and you are on grade at the centerline.

DIFFERENTIAL LEVELING

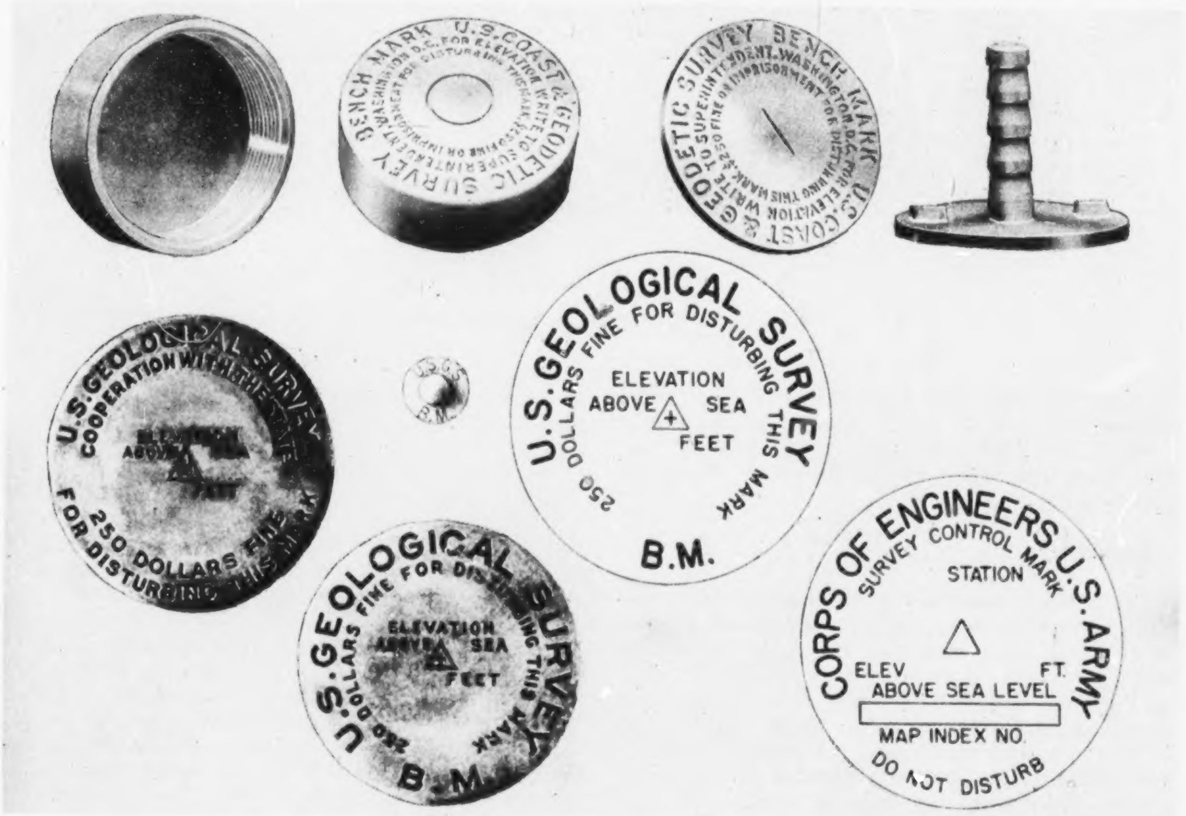
In order to set grade stakes, you must be able to measure the vertical distance from one point to another. This process is called DIFFERENTIAL LEVELING. The vertical distance of a point above some standard surface is called the ELEVATION of the point above the DATUM, which has an elevation of zero. The vertical distance which you will measure, then, is the DIFFERENCE OF ELEVATION between two points. Datum are of two general types, actual and assumed. An actual datum is mean sea level. An assumed datum plane is an imaginary level surface which is assumed to have an elevation of zero. It is used as a convenience to the levelman in leveling procedures. A reference point whose elevation is known and marked is called a BENCH MARK (B.M.). It is used either as the starting point in leveling or as a point of closure in checking the accuracy of your work.

Bench marks are classified as temporary or permanent. Temporary bench marks (T.B.M.) are established for the use of a particular job and are retained for the duration of that job. Throughout the United States a series of permanent bench marks has been established by various governmental agencies. These identification markers are set in stone, iron pipe, or concrete and are sometimes marked with the elevation above sea level. Typical markers are shown in figure 8-19.

Any substantial object may be used as a bench mark. Part A of figure 8-20 shows typical monuments set to mark important alignment points, but which may also be used as bench marks. Spikes may be driven into posts or power poles (part B, fig. 8-20) or into trees or roots (part C, fig. 8-20). Part D of figure 8-20 shows typical marks which may be chiseled into stone or concrete structures. For clarity, the marks are shown on the wing wall; but in practice, one mark only is usually chiseled on a flat surface.

The location, elevation, and description of bench marks are usually indicated on the construction plans or in the surveyor's field notes.

In measuring vertical distance, you will use a LEVEL. You may use an ENGINEER'S LEVEL mounted on a tripod, or a HAND LEVEL. Vertical


BENCH MARK U.S. COAST & GEODETIC SURVEY
GEODETIC SURVEY BENCH MARK U.S. COAST &
U.S. GEOLOGICAL SURVEY
COOPERATION WITH THE STATE
250 DOLLARS FINE FOR DISTURBING THIS MARK
U.S.G.S.
B.M.
U.S. GEOLOGICAL SURVEY
250 DOLLARS FINE FOR DISTURBING THIS MARK
ELEVATION
ABOVE
SEA
FEET
B.M.
U.S. GEOLOGICAL SURVEY
250 DOLLARS FINE FOR DISTURBING THIS MARK
ELEVATION
ABOVE
SEA
FEET
B.M.
CORPS OF ENGINEERS U.S. ARMY
SURVEY CONTROL MARK
STATION
ELEV
FT.
ABOVE SEA LEVEL
MAP INDEX NO.
DO NOT DISTURB

29.263:.264

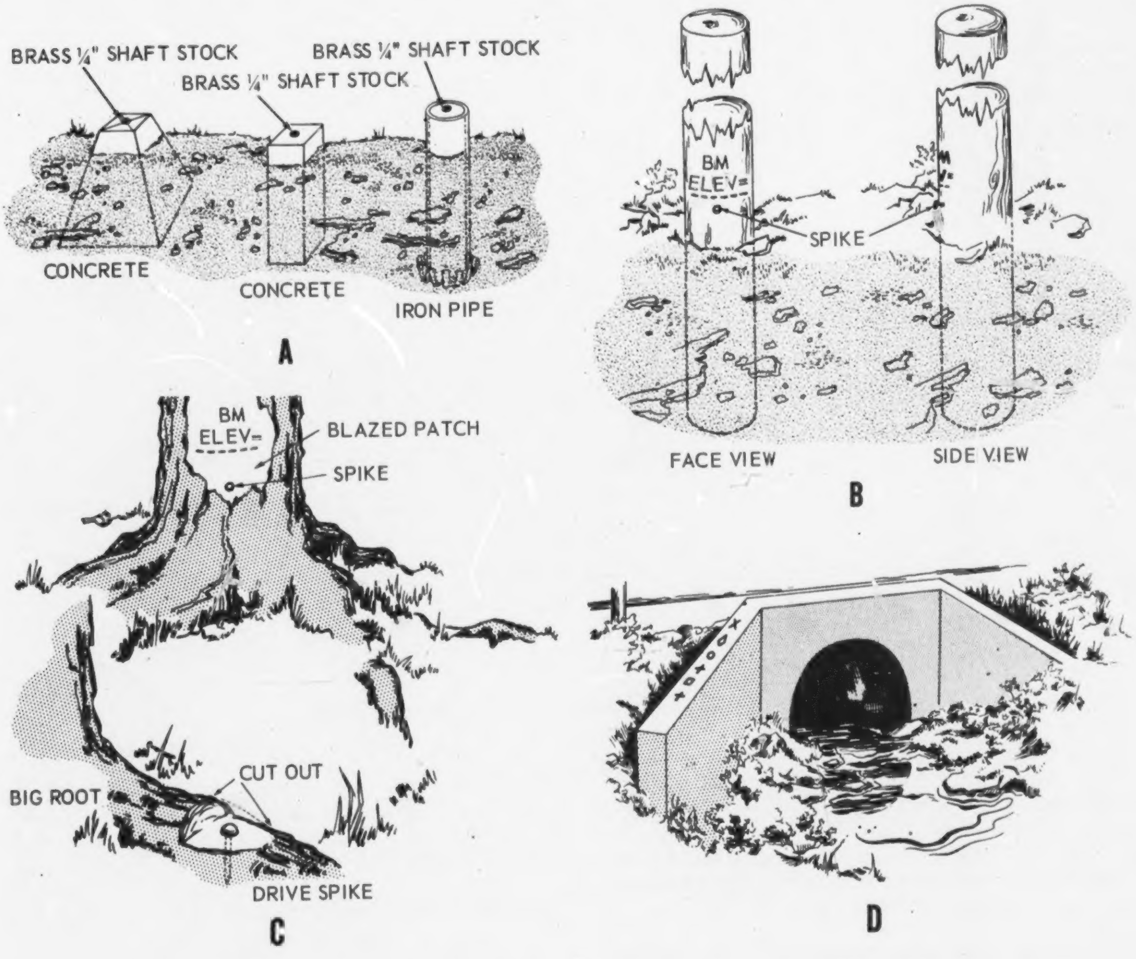
Figure 8-19.—Federal bench marks.

distances are actually measured by sighting on a graduated rod called a LEVEL ROD. Like other surveying equipment used for measuring distances, level rods usually are graduated in feet, tenths, and hundredths.

In leveling, a rod reading taken on a point whose elevation is known (the B.M. at A in fig. 8-21) is called a BACKSIGHT (B.S.), which is the 11.56 feet in figure 8-21. A backsight is also called a PLUS SIGHT because you add it to the known elevation (365.01 feet in fig. 8-21) to get the HEIGHT OF INSTRUMENT (H.I.), which is 376.57 feet in figure 8-21. A rod reading taken on a point whose elevation is to be determined (point B in the figure) is called a FORESIGHT (F.S.), which is the 1.42 feet in figure 8-21. A foresight is also called a MINUS SIGHT because you subtract it from the H.I. (376.57 feet in fig. 8-21) to get the elevation of the point to be determined (375.15 feet in fig. 8-21). The terms "backsight" and "foresight" do not necessarily refer to the direction of stationing on the survey line. A STATION, as used in leveling, is a point of unknown elevation which is to be determined.

LEVELING EQUIPMENT

Field work done by the EO is likely to consist of field measurements and placing the stakes. To perform this task, the EO must become familiar with equipment customarily used in work of this type. The term equipment refers, in general, to leveling instruments, tools, and devices which



(a) Horizontal control monuments
(b) Spike in a post or pole
(c) Spike in a root or tree
(d) Chiseled mark on concrete

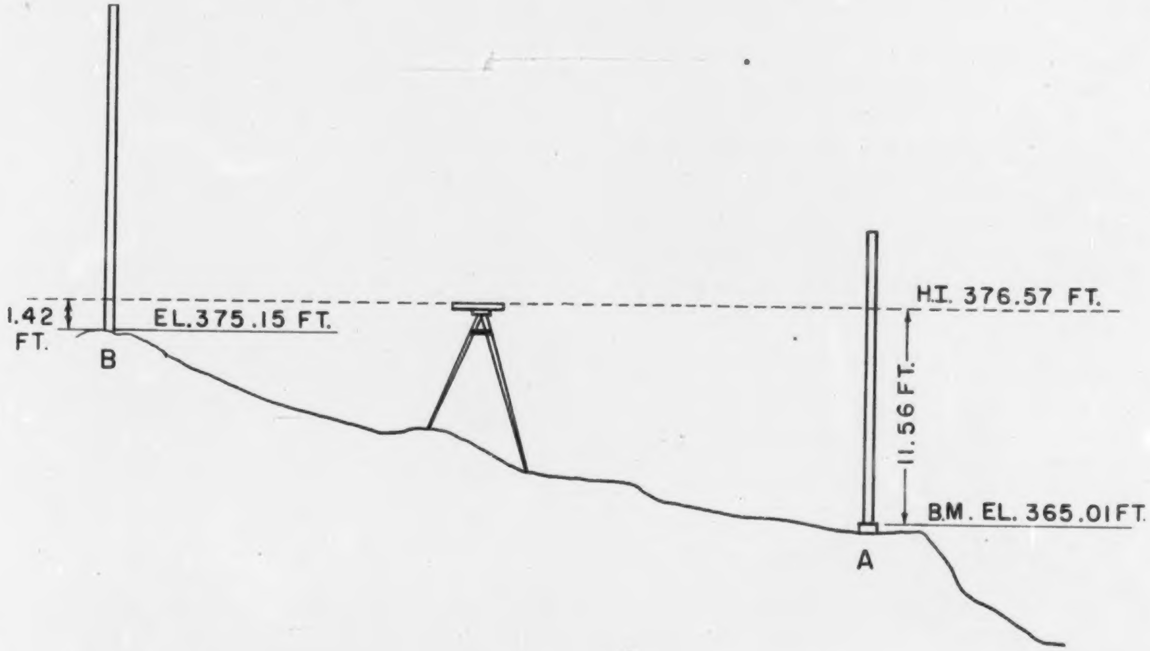
45.35

Figure 8-20. — Temporary bench marks.

are used indefinitely. The following is intended to describe leveling instruments and explain the basic procedures for their use.

Hand Level

The hand level, also called the Locke level (fig. 8-22) is a round or square metal tube about 6 inches long with an eyepiece at one end, a crosshair at the other end, and a level vial on top. Part of the crosshair end is covered with a mirror which shows the reflection of the bubble. When you look through the level, therefore, you can see the bubble and the level rod at the same time. When the crosshair is lined up with the middle of the bubble, the tube is level. You then read, on the level rod, the number crossed by the crosshair.

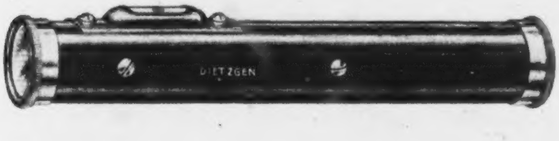


45.31

Figure 8-21.—Procedure for differential leveling.

The hand level is used for checking grade elevations or for setting grade stakes from other nearby grade stakes. The hand level is usually not used at distances greater than about 50 feet or even lesser distances if an accuracy of more than 2 or 3 tenths is required.

In using the hand level, it is sometimes necessary to know the height of the level above the ground where you are standing. This may be accomplished by resting the level on a stick of known length. This stick is known as a JACOB'S STAFF. Some specially made Jacob's staffs are adjustable. For rough work, you may ignore the use of a stick and merely use the height of your eye above the ground when you stand normally. You can get this value by standing next to a level rod.

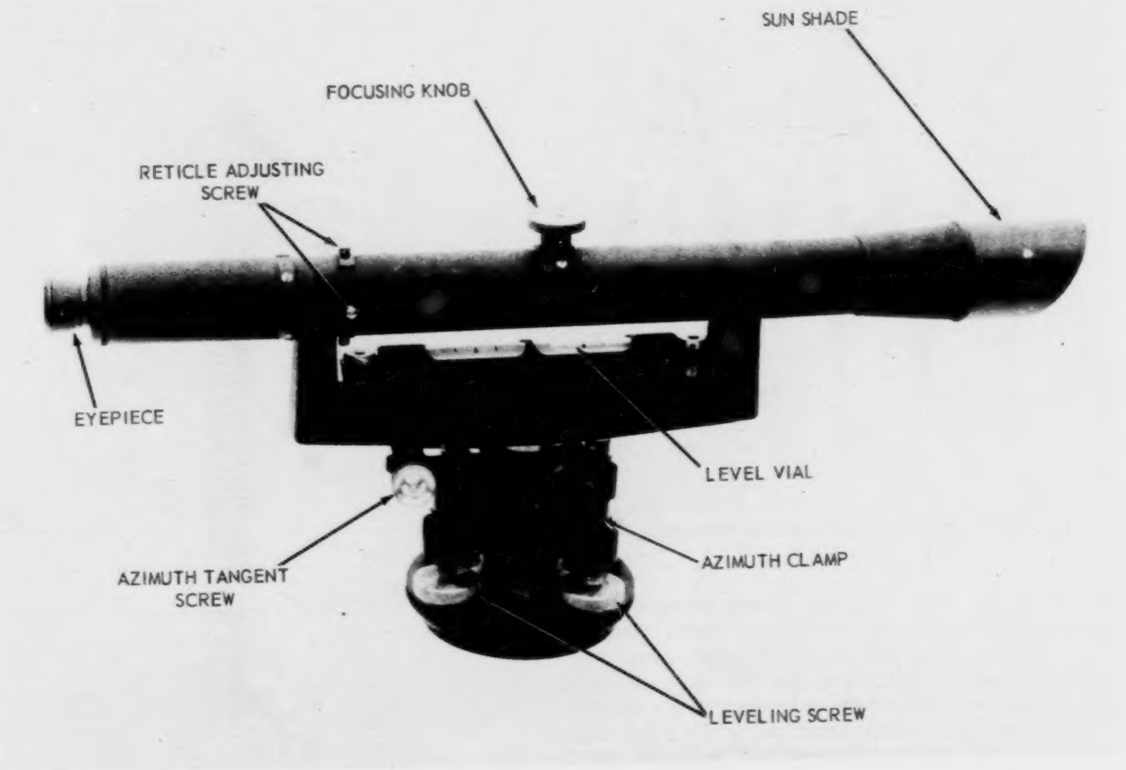


29.246X

Figure 8-22.—Hand level.

The Engineer's Level

The engineer's level, often referred to as the dumpy level, is a much more precise instrument than the hand level. It has a telescope that can be pointed horizontally in any direction. The tripod-mounted instrument is leveled at each set-up of the instrument by means of a sensitive bubble level vial. Telescope collars hold the telescope in a fixed position parallel to the level bar. The level bubble may be observed through an elongated port along the top of the level bar. A clamp screw and a tangent (or slow motion) screw below the level bar are used to align the instrument to an objective. These screws hold the level stationary while you are sighting. When the clamp screw is loose, the telescope can be rotated in a horizontal plane. When the clamp screw is



29.245A

Figure 8-23. — Dumpy level.

tight, the telescope can be rotated slowly with the tangent screw to get a perfect alignment.

There are various adjusting screws on the bubble tube and the level bar. You should not ordinarily attempt to make any adjustments to the instrument. Figure 8-23 shows a dumpy level.

Instrument Tripods

When in use, engineer's levels are supported on tripods. The footplate of each instrument is actually the tripod head nut and is threaded internally to fit on the tripod head.

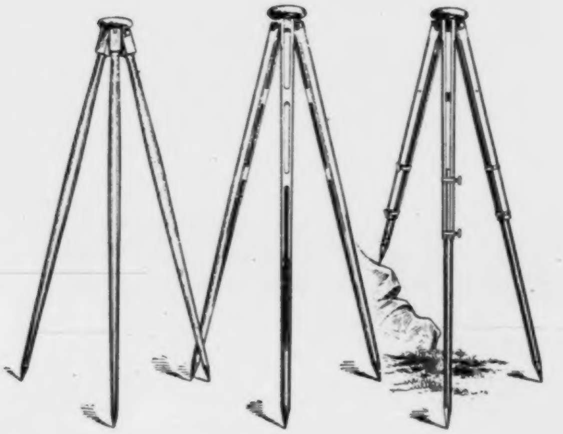
Tripod legs are made of wood with steel pointed tips. The steel tips are sometimes called metal shoes, or feet, and enable you to sink the legs into the ground to provide a firm footing.

Each leg is fastened to the tripod head with a bolt and a wing nut, that can be readily loosened to allow the legs to be moved freely. Always keep the wing nuts on the pivot points of the legs and head securely fastened when using a tripod in the field.

When a tripod is not in use, always SCREW the thread protector cap on. Never tighten it excessively. Some tripods with thread protector caps are shown in figure 8-24.

At times the instrument head may show a tendency to stick on the screw threads of the tripod head. When this happens, clean the internal and external threads of both heads with a suitable cleaning solvent.

Sometimes the head will stick so that the instrument will not unscrew, even though the



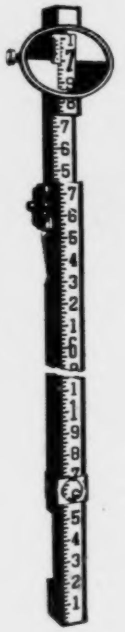
29.243X
Figure 8-24.—Instrument tripods.

threads may have worked freely when the instrument was set on the tripod head. Usually heat causes this sticking. Expansion of the threads causes the flanged surface at the base of the tripod head screw to lock against the bottom edge of the instrument level plate. To avoid this locking, just secure the threaded section—don't tighten it excessively. This is essential since a temperature change of only a few degrees will cause tightening.

When you wish to loosen an instrument head which is stuck, grasp the instrument level plate and screws with both hands. Use a tight hold, particularly on the knurled surface. Brace yourself and turn counterclockwise.

Level Rod

The level rod must commonly used is the Philadelphia rod shown in figure 6-25. The face of the scale is painted white. The graduation marks, which are 0.01 foot wide and spaced 0.01 foot apart, are painted black. The numbers indicating feet are painted red, and those indicating tenths of feet are painted black. The lower or ground end of the rod is the zero point from which graduations are numbered. This end of the rod is covered with a metal shoe for protection against wear. The rod usually comes in two sliding sections, with a thumb screw for adjusting the rod to either short (below 7 feet) or long (from 7—13 feet) lengths.



29.265X
Figure 8-25.—Philadelphia level rod with target.

The Philadelphia rod is also equipped with a target which can be set and clamped by the rodman at the direction of the levelman. The indicated reading is observed either by the levelman or rodman, or both. The Philadelphia rod, therefore, can be used either as a self-reading or as a target rod.

When the sections of the Philadelphia rod are closed, a vertical distance of slightly more than 7 feet can be read. When a reading is more than 7 feet, the back section of the rod is pushed upward and the 7-foot mark at the top of the rod becomes actually the 13-foot mark on the front of the rod.

The level rod is a calibrated (accurately subdivided) rule. You can't expect it to give you accurate measurements unless you protect it well. Always place the base of the rod lightly on a point until it is firmly surfaced. Banging the rod ruins its accuracy.

A rod should never be laid flat on the ground or deck unless it is protected from rough treatment. Numerals and graduations are easily scratched. Measurements are worthless if taken from a rod whose numerals and graduations cannot be clearly seen. Also, scratched numerals and graduations make observing extremely difficult for the levelman.

The wood in a rod will swell in very damp climates or when the rod is used excessively in water. Try to keep the rod as dry as possible. Never leave mud on it. Wash mud off; don't rub it.

OPERATION OF THE ENGINEERS LEVEL

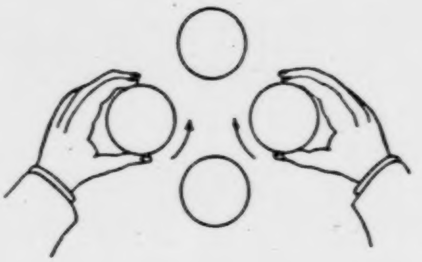
As an EO, you may be assigned to assist in taking direct readings and target readings of elevations. For success in these operations, it is important that the level first be set up properly.

Setting Up Level

The first step in using the level is screwing the instrument onto the head of the tripod. Set the tripod up securely with the legs evenly spaced. Remove the thread protector cap. Then, take a firm hold on the instrument, and carefully remove it from the box, making sure that the clamp is loosened. Next, place the level head threads over the guide section of the tripod head threads, supporting the instrument with your left hand. Mesh the threads by twisting easily to the right — NEVER FORCE — until the two heads are secured together, but not cinched. Remove the telescope dust cap and replace it with the sunshade.

When you set up a level instrument on level ground, spread two of the tripod legs to the desired width between the tips. Swing the third leg out to the desired position to bring the level plate as close to true level as possible. Ease all three tips down at the same time. If the level plate is much off, move the leg involved to level it up. Be sure to press the tripod leg tips into the ground to ensure solid footing.

Turn the telescope so that it is directly over two opposite leveling screws. Then level the telescope by bringing the bubble to the center of the tube using this set of leveling screws. Use both hands, and turn the opposite level screws in opposite directions, as shown in figure 8-26. In doing this you will notice that your thumbs move either towards or away from the center of the tripod. The level bubble of the instrument will follow the direction of your left thumb. Now swing the telescope so that it is directly over the other set of screws. Bring the bubble back to the center of the tube. To check your leveling, swing the telescope back in line with the first set of screws adjusted, then swing it in line with the second set. The bubble should remain in the center of the tube. If not, repeat the process. Level screws should seat firmly on the level plate but they should not be tight. Cinching any part of an instrument ruins its precision.



45.95

Figure 8-26. — Manipulating level screws.

The next step is to focus the crosshairs to suit your eye. Look through the telescope and rotate the eyepiece until you can see the crosshairs clearly. Then point the telescope at the rod. Secure the telescope with the clamp. Bring the rod into focus by rotating the knob on top of the telescope. Last, bring the crosshairs onto the rod by using the slow motion screw.

The first rule in the care of the instrument is to handle it gently because many of its parts are made of soft metal. Never use brute force on any of the movable parts. All screws should work easily. Avoid tightening the clamps excessively. Failure to heed this precaution will cause excessive wear on the threads. Be careful in cleaning the optical glass of the telescope to avoid scratching the precision-ground surface; use a camel hair brush.

Before using any oil on a surveying instrument, make sure that the instrument is clean.

Well protected bearings should first be cleaned with a suitable cleaning solvent and then oiled lightly. Excessive grease or oil tends to accumulate dust on the instrument. A light coat of watch oil or fine instrument oil is sufficient.

Oil congeals in cold climates and causes moving parts to stick and bind. You can use instruments with no lubrication, or you may apply a special, fine graphite powder to screws and moving bearing surfaces to avoid this trouble.

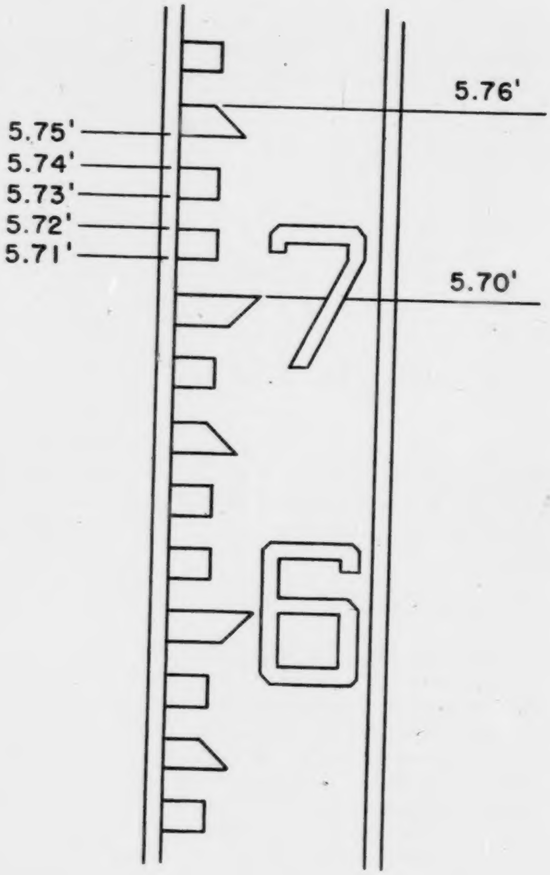
When instruments are not in use, ALWAYS place them in their boxes for safety and security. Every surveying instrument comes equipped with a carrying box. These boxes usually are of light, hardwood construction with either a hinged top or front face door. In taking the level out of the carrying case, do not lift it by the telescope. Grasp the instrument under the leveling base or foot plate to avoid damaging the delicate parts.

When carrying an instrument from one setup point to another, adjust the level screws so that the leveling head and the foot plate are about parallel and the level screws are just slightly loose against the foot plate. Adjust the clamp screw so that it is tight enough to prevent excessive wear, yet loose enough to yield if the instrument is accidentally bumped.

If you are carrying the instrument in open country, it is best to balance the tripod and instrument over your shoulder. Your arm should encircle the legs of the tripod.

Direct Readings

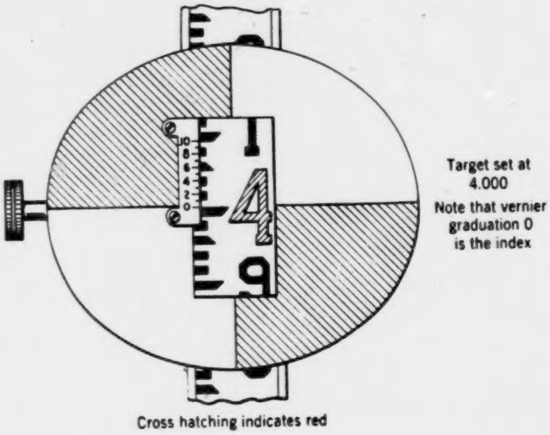
As the levelman, you may make direct readings on a self-reading rod held plumb on the point by the rodman. If you are working to tenths of a foot, it is relatively simple to read the foot mark below the crosshair and the tenth mark which is closest to the crosshair. But, if greater precision is required, and you must work to hundredths, the reading is more complicated.



45.96
Figure 8-27.—Direct reading of 5.76 ft. on Philadelphia rod.

For example: suppose you are making a direct reading which should come out to 5.76 ft. If the rod is a Philadelphia rod, the interval between the top and the bottom of each of the black graduations, the interval between the top of a black graduation and the bottom of the next higher graduation, and the interval between the bottom of a black graduation and the top of the next lower graduation, all represent 0.01 ft. For a reading of 5.76 ft, then, there are 3 black graduations between the 5.70-ft mark and the 5.76-ft mark, as shown in figure 3-27. Since there are 3 graduations, a beginner may have a tendency to misread 5.76 ft as 5.73 ft.

As you can see, neither the 5-ft mark nor the 6-ft mark shows the figure 8-27. Sighting through the telescope, you might not be able to see the foot marks if you are close to the rod. It is the 5-ft mark to which you must refer the reading. When you can't see the next lower foot mark through the telescope, it is a good idea to order the rodman to "Raise for red." The "red" has reference to the fact that the numerals which indicate whole feet on the Philadelphia


Target set at 4.000
Note that vernier graduation 0 is the index
Cross hatching indicates red

29.267

Figure 8-28. — Target.

rod are in red. When the rodman hears this order, he slowly raises the rod until the next lower red figure comes into view.

Target Readings

When a target reading is being taken, the horizontal separation line of the red and white quadrants of the target (fig. 8-28) is set by the rodman from signals given by the levelman. The levelman motions either up or down so that the rodman can place the target's horizontal separation in line with the horizontal crosshair of the instrument. When the horizontal separation and the horizontal crosshair coincide, the levelman waves ALL RIGHT. The rodman tightens the target clamp. Then the rodman holds the rod on the point again to make sure that the target has not slipped, and "waves" the rod to determine if the rod was initially held in an absolutely vertical position. The rodman "waves" the rod by pushing it away from and toward himself about a foot in each direction. If the rod was initially out of plumb, the levelman will observe that at one point during the "waving" procedure the center of the target is above the horizontal crosshair. If this occurs, the target must be reset.

When the rodman gets an ALL RIGHT from the levelman, he reads the rod to feet, tenths, and hundredths of the nearest graduation below the target's horizontal quadrant separation line. The vernier on the target (fig. 8-28) is used to take readings to the thousandth of a foot. As an EO, you will probably never be working that close; so ignore the vernier.

To take a target reading above the lower section of the rod, set the target accurately on the foot graduation closest to the top of the rod. Loosen the thumb-screw clamp. Slide the back section with the target up until a signal from the levelman indicates that the horizontal line of the target is in line with the horizontal crosshair of the level instrument. Now tighten the thumbscrew of the rod clamp. Check the target alignment with the level instrument again by "waving" the rod.

You will notice that the graduations on the back of the rod are numbered from the top down. This is the reverse of the numbering on the front of the rod. In reading the back of the rod, observe the nearest foot, tenth, and hundredth above the zero of the vernier on the rod clamp.

CHECKING GRADE WITH THE HAND LEVEL

The simplest leveling procedure you will perform is checking the amounts of cut or fill against the known elevations of existing grade stakes with the use of the hand level and level rod.

First, you must determine your height of eye level. Place the level rod on level ground, and sight through the eyepiece of the hand level, making certain that the hand level is level, and read directly on the level rod. The reading which you obtain will be your constant height of eye level.

Find a point that is exactly at or near grade; a hub stake, a blue or red top stake, or a stake marked "grade". Take your position over the stake that is to grade while your helper holds the level rod straight up and down with the end of the spot you want to check. Sighting through the hand level in a level position, read the feet and tenths of a foot on the level rod which is intersected by the crosshair of the hand level. If your eye level is 5.6 feet and the level rod reading is 5.6 feet, this means that the spot on the ground that you are checking is at grade. If the rod reading is 6.6 feet, it means that the spot you are checking must be filled an additional 1.0 foot. If the rod reading is 4.6 feet, it means that the spot you are checking is 1.0 foot too high and you will have to cut 1.0 foot. From this example, you can see that if the rod reading is greater than the height of the eye level reading, the spot being checked is low by the difference between the rod reading and the height of eye level reading. And

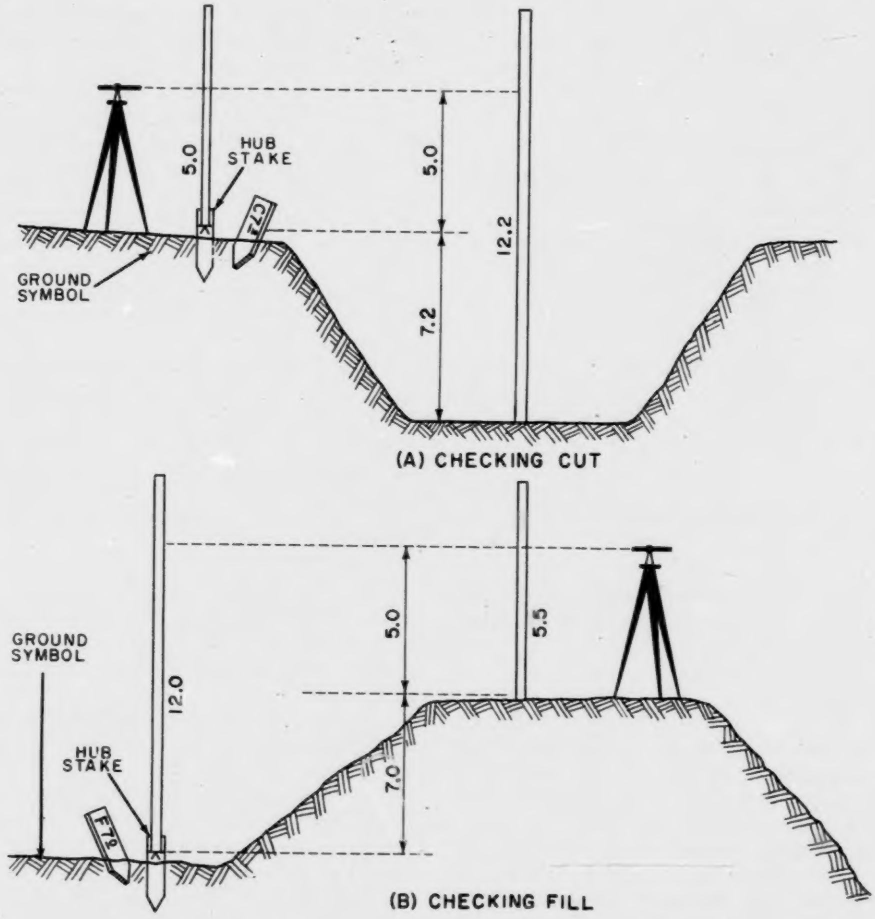


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Figure 8-29. — Checking cut and fill.

if the rod reading is less than the height of eye level reading, the spot being checked is high by the amount equal to the difference between the height of eye level reading and the rod reading.

LEVELING PROCEDURES WITH THE ENGINEER'S LEVEL

If you have access to an engineer's level the leveling procedures explained for the hand level may be more accurately performed with this level.

An example of checking ground spots for desired grade with the engineer's level is shown in figure 8-29. The hubs and stakes at the side of the construction represent offset grade stakes. In part A of figure 8-29, the grade stake calls for a cut of 7.5 ft. You set up your level and take two readings: first on the hub and then on the excavation. Your first reading is 5.0 ft. Since the excavation is supposed to be 7.5 ft below the hub, your second reading should be 12.5 (5.0 plus 7.5 as shown). But the rod reads only 12.2; therefore, you must cut 0.3 ft more to get to finished subgrade.

In part B of figure 8-29, your first reading is 12.0 ft on the hub. Since the stake calls for

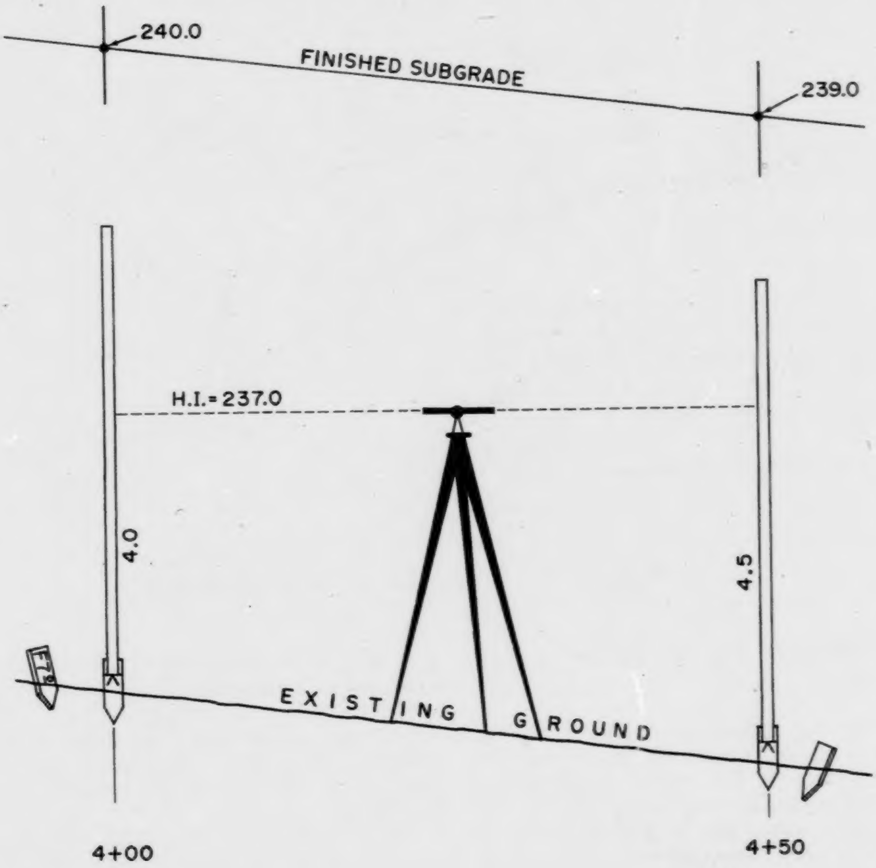

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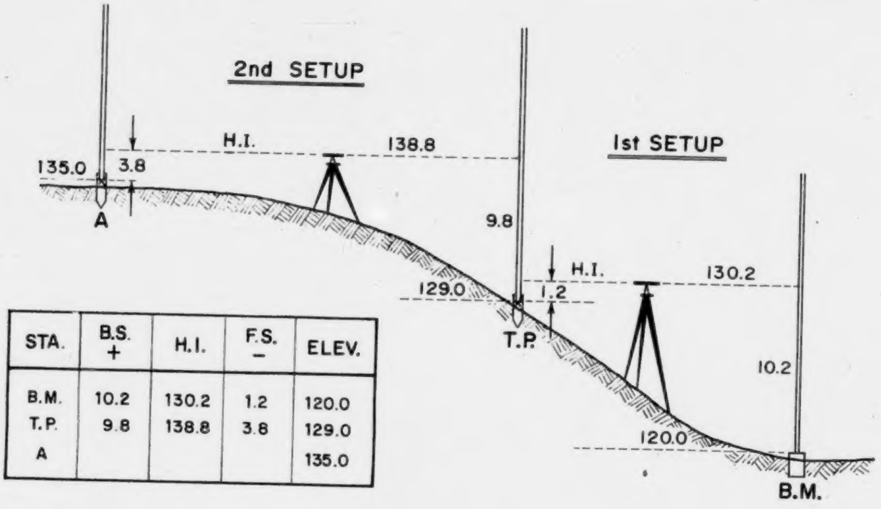
Figure 8-30. — Replacing a missing grade stake.

F 7.0, you should read 5.0 on the completed fill. But the rod reads 5.5; therefore, you must fill another 0.5 ft to finished subgrade.

Another leveling procedure you will probably have to perform is the replacement of a missing grade stake. Refer back to figure 8-21. Suppose that point B at station 10 + 00 is 378.75. You set up your level, backsight on A, add the plus shot, and figure your H.I. Then you foresight 10 + 00, subtract the minus shot, and determine that the existing ground is at elevation 375.15. Since finished subgrade is to be 378.75, you must FILL 3.6 ft at sta 10 + 00 (378.75 - 375.15 = 3.60).

Figure 8-30 illustrates another example. Suppose that the stake at station 4 + 50 has been knocked out, that there is no bench mark nearby, that you don't have any field notes showing existing hub elevations, but that you do have a set of plans and nearby cut or fill stakes. You observe that the plans call for finished subgrade of 240.0 at 4 + 00 and that the stake calls for a fill of 7.0 ft. Therefore, the elevation of the hub at 4 + 00 is 233.0 (7.0 ft below 240.0). You set up your level and take a backsight of 4.0 ft on 4 + 00, giving you an H.I. of 237.0) (233.0 plus 4.0 equals 237.0). Then you foresight on your new hub at 4 + 50 and get a reading of 4.5 ft. You subtract 4.5 from 237.0 and figure the new hub elevation to be 232.5. Since the plans show that the finished subgrade at 4 + 50 is going to be 239.0, you must FILL from



STA.	B.S. +	H.I.	F.S. −	ELEV.
B.M.	10.2	130.2	1.2	120.0
T.P.	9.8	138.8	3.8	129.0
A				135.0

115.74

Figure 8-31.—Turning point and level notes.

232.5 up to 239.0, or 6.5 ft. You mark your new stake F 6.5.

In the foregoing examples you were basing your elevations on nearby points which could be read from one setup of the level. If differences of elevation or distances are too great, or if there are obstructions, you will have to make an intermediate setup and sight on a point called a TURNING POINT (T.P.). Any convenient point may be used as a turning point, but the rod must be set on firm ground or on some firm object so that the elevation of the T.P. won't change while the rodman waits for the levelman to set up at the new position. If you are running levels up a fill slope with a loose surface, for example, drive a stake into the fill for use as a T.P. Figure 8-31 shows a typical level run which includes a T.P.; the level notes are also shown. In this case, you have a B.M. at the bottom of a bank and you want to find the elevation at A. But if you set up on the top of the bank so that you can read the rod held on A, you can't read the rod held on the B.M. because the rod isn't long enough. First, you record the B.M. elevation (120.0). Next, set up on the bank, backsight on the B.M., and add the reading (10.2) to the B.M. elevation to get the first H.I. (130.2). Then foresight on the rod held on the T.P. and subtract the reading (1.2) from the H.I. to get the T.P. elevation (129.0). Next, move the instrument to the top of the bank. Backsight on the T.P. and add the reading (9.8) to the T.P. elevation to get the new H.I. (138.8). Last, foresight on point A and subtract the rod reading (3.8) from the H.I. to get the elevation at point A (135.0).

Some level runs may require more than one T.P.; but no matter how extensive the job, the procedure is always the same: you add and subtract successive rod readings from a point of known elevation to the point of unknown elevation.

Errors and Mistakes

A special effort should be made to avoid errors and mistakes in leveling. Some of the common errors and mistakes to watch for are pointed out below.

Inaccurate Adjustment of the Instrument—The most common instrument error is caused by the level being out of adjustment. The instrument must be adjusted so that the line of sight is horizontal when the bubble is in the center of the tube.

Errors in Sighting—If the eyepiece of the telescope is not properly focused, the rod reading will appear to change as the position of the eye is changed with respect to the eyepiece.

Errors Due to Changes in the Position of the Instrument — if the instrument is not properly leveled, or if it is set up in an unstable position, errors due to settlement will result. An unstable instrument setup is indicated by a slight trembling of the level bubble even though it appears to be properly centered. It is important to check the position of the bubble before and after each rod reading to make sure that the bubble has remained in the center of the tube.

Faulty Handling of the Rod — The rod may not be properly plumbed. If the rod is not held plumb — that is- if it leans toward or away from the instrument — it will result in an excessive reading.

Erroneous Rod Length — Check the length of the extended leveling rod with a steel tape.

An Unstable Object Used for a Turning Point — If necessary, drive a hub or stake for use as a T.P.

Failure to Hold the Rod on the Same Turning Point for Any One Instrument Setup — Careful marking of the turning point will ensure that the rod is being held on the same turning point for both the backsight and the foresight.

Failure to Set the Target Accurately When the Philadelphia Leveling Rod is Used in an Extended Position — Check the position of the target after it has been clamped to make sure that it has not slipped. The position of the target should also be checked before and after each sight.

Failure to Clamp the Rod at the Proper Place When a High Rod is Used by the Instrumentman — This error could result in reading the wrong mark on the rod or reading the wrong crosshairs. The clamped positions should be inspected before and after each sight to make sure that the extended rod has not slipped down.

Entering A Rod Reading in the Wrong Column of the Field Notes — The most common error is to enter a backsight (B.S.) under the foresight (F.S.) column, and a F.S. reading in the B.S. column.

Mistakes in Arithmetic — Always check your addition and subtraction.

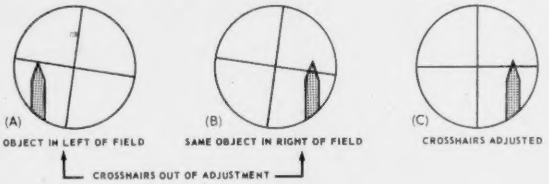


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Figure 8-32. — Testing horizontal crosshair.

Testing the Level

There are two tests you should run occasionally on the level to see whether or not it is in adjustment.

The first test indicates whether or not the horizontal crosshair is truly horizontal when the instrument is level. First, set up the instrument and level it. Sight a sharply defined point and set the left end of the crosshair on the point (part A, fig. 8-32). Slowly turn the telescope to the left. If the crosshair does not stay on the point (part B, fig. 8-32), the crosshairs are out of adjustment. If the crosshair follows the point (part C, fig. 8-32), the crosshairs are in adjustment.

The second test, called the TWO-PEG test, indicates whether or not the line of sight is horizontal when the bubble is in the center of the tube (see fig. 8-33). Set up and level the instrument midway between two hubs 200 ft apart. Read the rod on both hubs and compare the readings. In part A, figure 8-33, for example, the rod readings of 1.00 and 5.00 show that hub B is 4.00 ft lower than A. Next, move the instrument to hub A, level it up, and read the rod opposite the eyepiece (5.00 in part B, fig. 8-33). Then read the rod held on hub B. Since B is 4.00 ft lower than A, and since the instrument is 5.00 ft above A, you should read 9.00 ft (5.00 plus 4.00) on the rod at B. If you don't, the instrument is out of adjustment.

If either of these tests indicates that the level is too far out of adjustment to suit the precision of the work you are doing, get an EA to make the necessary adjustments.

MEASURING HORIZONTAL DISTANCES

In the foregoing sections of this text, you have been told how to measure vertical distances

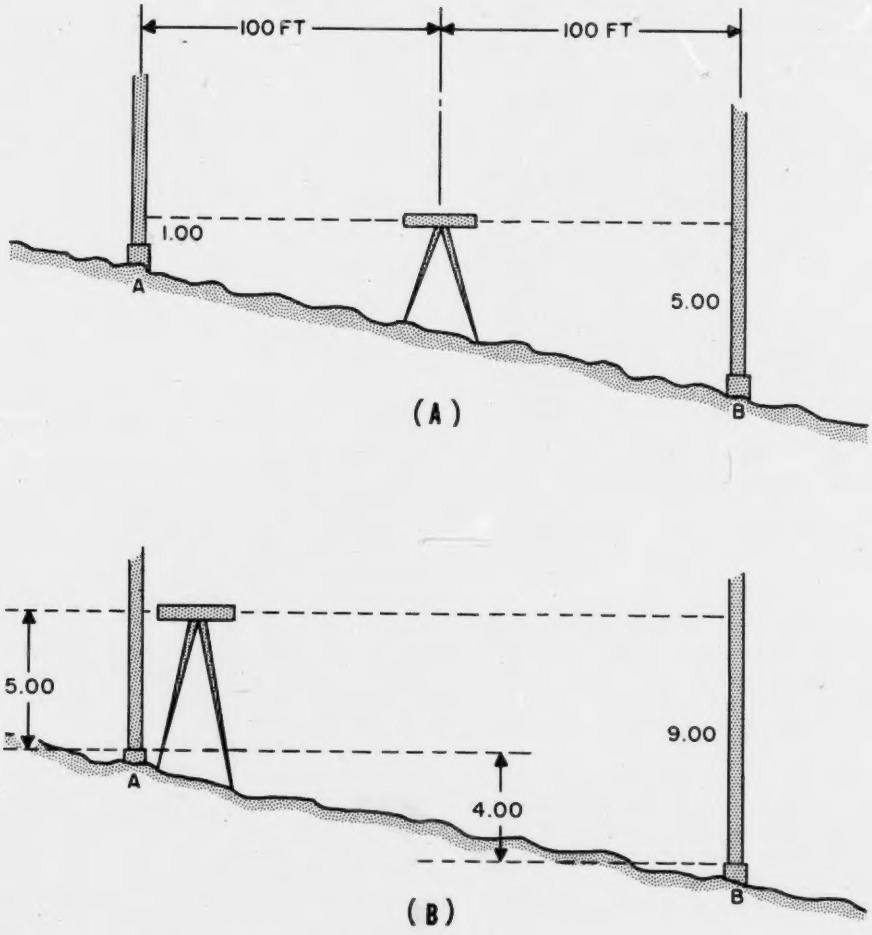

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Figure 8-33.— Two-peg test.

with a level and rod. But, in order to set or replace grade stakes, you will also have to measure horizontal distances. To do this, you will generally use either a WOVEN TAPE or a STEEL TAPE (called the CHAIN by surveyors).

A woven tape is made of high-grade cloth (usually linen) fabric. A METALLIC woven tape is reinforced with fine bronze or brass wire mesh; a NONMETALLIC woven tape does not contain the mesh. Some nonmetallic woven tapes are coated with plastic.

Woven tapes are made in 25-, 50-, 75-, 100-, and 150-ft lengths. Some are graduated in feet and inches to the nearest quarter-inch. Others are graduated in feet and decimals of a foot to the nearest 0.05 ft. On most decimally-graduated woven tapes, only the 0.10-ft graduations are marked with numerals, as shown in figure 8-34.

For measurements requiring greater precision than is obtainable with the woven tape, the steel tape is used. The most commonly used steel tape is 100 ft in length and is graduated in feet, tenths, and hundredths. Some steel tapes are graduated throughout; on others, only the first foot is graduated in subdivisions and the body of the tape is graduated only at every 1-ft

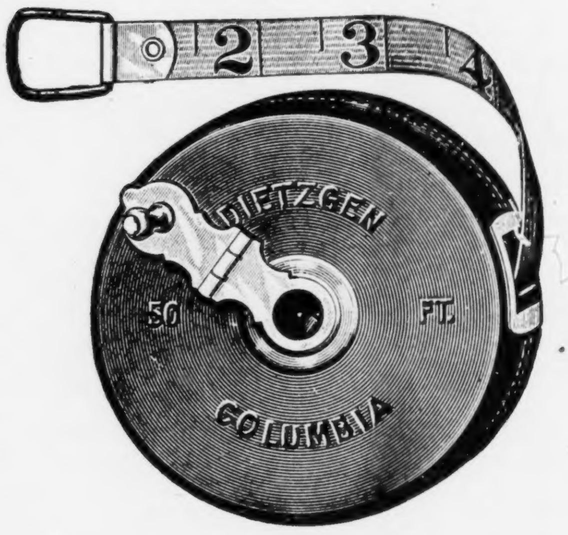

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Figure 8-34. — Woven tape.

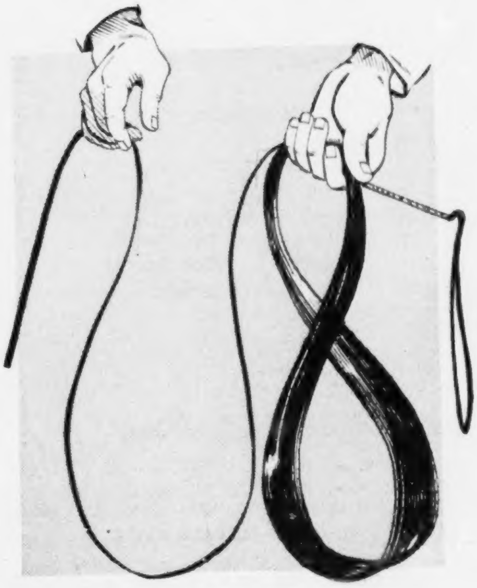

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Figure 8-35. — Doing up a steel tape.

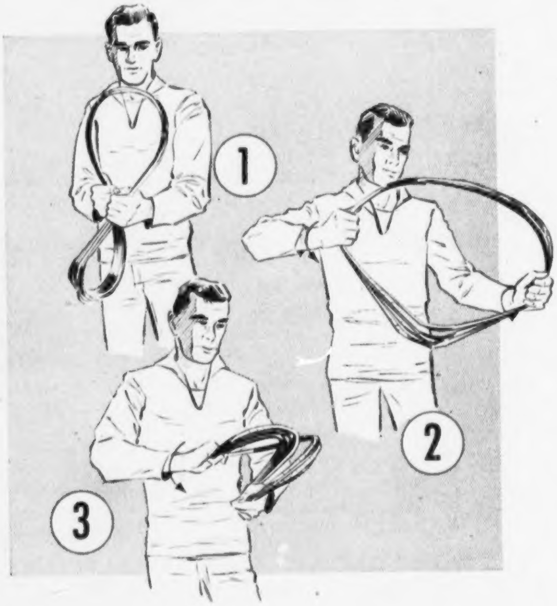

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Figure 8-36. — Throwing a steel tape into a coil.

mark. A steel tape is sometimes equipped with a REEL, on which the tape can be wound. The tape can be, and often is, detached from the reel, however, for more convenient use in taping.

For convenience in carrying from one place to another, a detached tape can be made up into a coil (called DOINT UP the tape) by the following procedure: Place the 100-ft end (or the 200-, 300-ft, etc., end) in your left hand, face up; then reach back with your right hand, grasp the 95-ft mark, bring it up, and place it face up on top of the 100-ft mark. Do the same with the 90-ft mark, the 85-ft mark, the 70-ft mark, and so on, until you have gathered in the entire tape. You'll find that the tape now forms a figure-of-eight, as shown in figure 8-35. You can THROW the figure-of-eight into a circular coil, as shown in figure 8-36.

SETTING GRADE STAKES

There are a number of procedures which you may use in setting grade stakes. One of these is as follows:

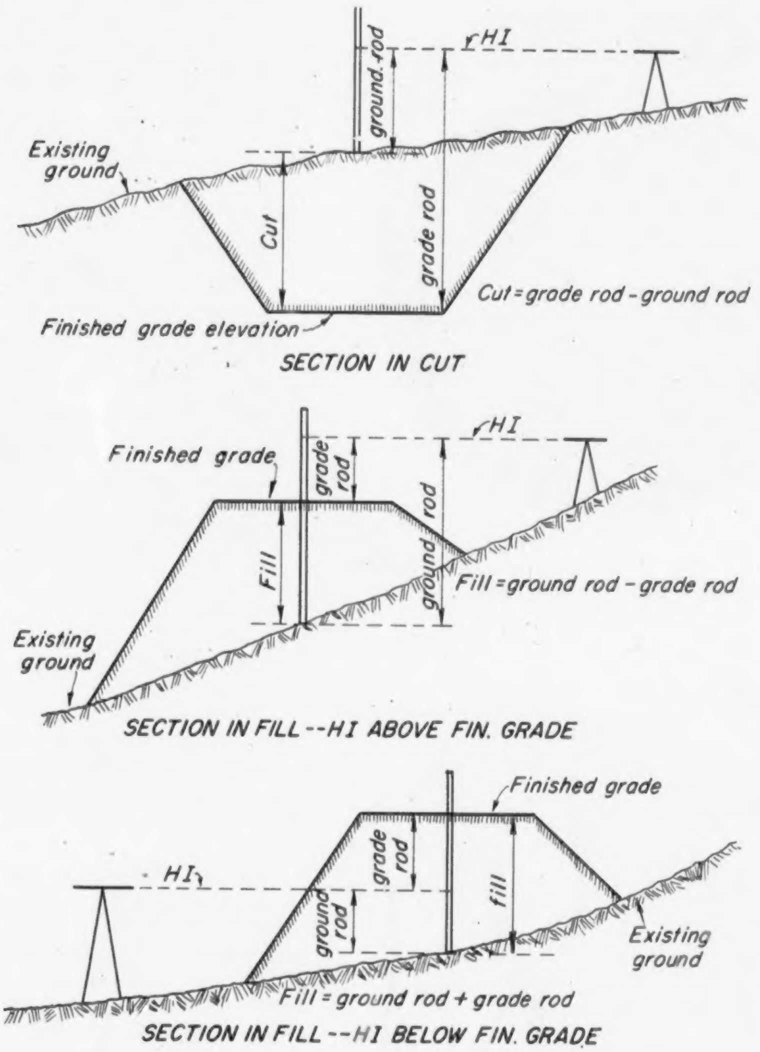

Figure 8-37. — Computing cut or fill from grade rod and ground rod.

1. From bench marks, turn levels on the centerline hubs (or on the ground next to the stakes) and determine the hub (or ground) elevations.
2. From the construction plans, determine the finished grade elevation at each station.
3. Compute the difference between the finished grade and the hub (or ground) elevations to obtain the cut or fill at each station.
4. Go back down the line of stakes and mark the cut or fill on each stake.

The elevations and cuts and fills may be recorded in the level notes, or they may be shown on a construction sheet or cut sheet.

Another procedure that may be used to set grade stakes combines the foregoing operations so that the calculations are completed while at each station, and the cut or fill may be marked on the stake immediately. As before, levels are run from BM'S; the procedure at each station is as follows:

1. Determine the H.I. from the level notes.
2. Determine the finished grade from the plans.
3. Compute the difference between the H.I. and the finished grade: the result is called the GRADE ROD.
4. Hold the rod at the point (or hub) for which the cut is desired; read the rod. This rod reading is called the GROUND ROD.
5. Compute the cut or fill by adding or subtracting the grade rod and ground rod as shown in figure 8-37.
6. Mark the cut or fill on the stake.

The general procedure for setting blue tops is as follows:

1. Consult construction plans and centerline profiles to determine exact elevations and the distance from the centerline to the edge of the shoulder.

2. At each centerline station, measure the distance from the centerline and drive a grade stake at the edge of each shoulder. Sometimes it is advisable to offset these stakes a few feet to avoid their being displaced during construction.

3. Set the top of the stake even with the grade elevation, using a level and a rod. This is done by measuring down from the H.I. a distance equal to the grade rod, which is determined by subtracting the desired grade elevation from the H.I. The rod target is set at this grade-rod reading; the rod is held on the top of the stake; and, after a few trials, the stake is driven into the ground until the horizontal hair of the level bisects the target; at this point, the top of the stake is at grade elevation.

CHAPTER 9

TRACTORS AND ATTACHMENTS

A tractor may be used simply as a PRIME MOVER to tow or push another piece of construction equipment (a scraper, for example). Or, it may be used, equipped with one of several types of ATTACHMENTS (such as a dozer blade or a winch), as a self-contained piece of construction equipment. In selecting a tractor, you must consider the job for which it will be used, such as bulldozing, pulling a scraper, or ripping. Other factors to consider are the length of haul and the terrain to be worked. Tractors are indispensable in practically all road and airfield construction operations.

Many different makes, models, and sizes of tractors are used by the Navy's Construction Force. You will find, however, that most of the Navy's tractors are either the crawler type or the rubber-tired type.

General information on starting, operating, and maintaining crawler and rubber-tired tractors and their attachments is given in this chapter. Also included is information on the capabilities, gross limits, optimum working distances, and utilization of tractors; recognition of hand signals used during tractor operations; procedures to follow when changing tires and attachments; and safety precautions to be observed when changing tires and when operating, or working near, tractors.

USE OF TRACTORS AND ATTACHMENTS

Tractors and attachments used by the Navy are designed primarily to ensure the performance of earthwork functions under varied conditions. Design specifications and performance characteristics of tractors and attachments developed for military use indicate their capabilities and limitations under adverse conditions. EOs must recognize these capabilities and limitations to make the most efficient use of tractors and attachments which they may operate.

CRAWLER-TYPE TRACTOR

The crawler type tractor is perhaps the most basic and versatile machine in the construction field. (See fig. 9-1.) It is used where maximum power is required at relatively low speeds and operates particularly well on loam or gravel. You will find the crawler tractor especially suited for sidehill excavations. It is preferred to the rubber-tired tractor for this purpose because of the lower center of machine gravity, better traction, and stability. The crawler tractor can be used as a power unit for winches, hoists, and side booms.

Crawler tractors are usually rated by size and power. The pull developed at the drawbar is expressed in pounds or as drawbar horsepower. At a low gear, the drawbar pull is greater; as the speed increases, the drawbar pull decreases. Although the specifications for crawler tractors may vary among the different manufacturers, the maximum speeds are seldom in excess of 7 mph.

The crawler type tractor is used primarily where it is advantageous to sacrifice high travel speed to obtain high drawbar pounds pull and traction. The crawler tractor attains much of its all-type-terrain versatility from its low ground bearing pressure at the track, which varies from about 6 to 9 pounds per square inch, depending on the particular model. Crawler tractors have a distinct "flotation" advantage over rubber-tired tractors which have a bearing pressure of about 25 to 35 pounds per square inch. Crawler tractors can operate in muck or water as deep as the height of the tracks. Operation in deeper water is possible, for short periods of time, if the tractor is properly waterproofed. For long moves, crawler tractors should be transported on heavy trailers. They may be moved under their own power at slow rates of speed but this shortens their operational life.

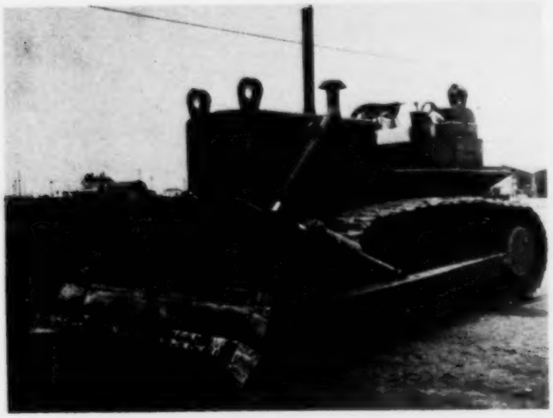

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Figure 9-1. — Typical crawler tractor with dozer blade.

RUBBER-TIRED TRACTOR

Rubber-tired tractors are the result of efforts of the construction industry to obtain units with higher travel speed than are possible with crawler tractors. Many rubber-tired tractors presently available have maximum speeds in excess of 30 mph. One type of rubber-tired tractor used by the SEABEES is shown in figure 9-2.

Rubber-tired tractors are capable of providing many of the same functions as crawler tractors, and are used in conjunction with crawler tractors on many projects. The high travel speeds possible with rubber-tired tractors give them an advantage on jobs requiring travel over considerable distances. However, the high speeds are obtained at the expense of pulling effort.

Rubber-tired tractors are used where hauls are long enough to develop high average haul and return speed, or where tracks would be harmful to surfaces under construction. These tractors operate well on loam, gravel, smooth rock, or paved surfaces. Recent improvements in design give rubber-tired tractors almost the same traction capability, under normal conditions, as the crawler type, but full drawbar pull cannot be attained in sand or mud because of tire slippage. Slippage on some rubber-tired tractors is largely overcome by using weight transfer devices, which transfer some of the load weight to the drive wheels of the tractor. In dire emergency and under the direct authorization of the leading petty officer, deflating the tires slightly will reduce slippage to a certain extent. The high speed of rubber-tired tractors makes them particularly desirable as prime

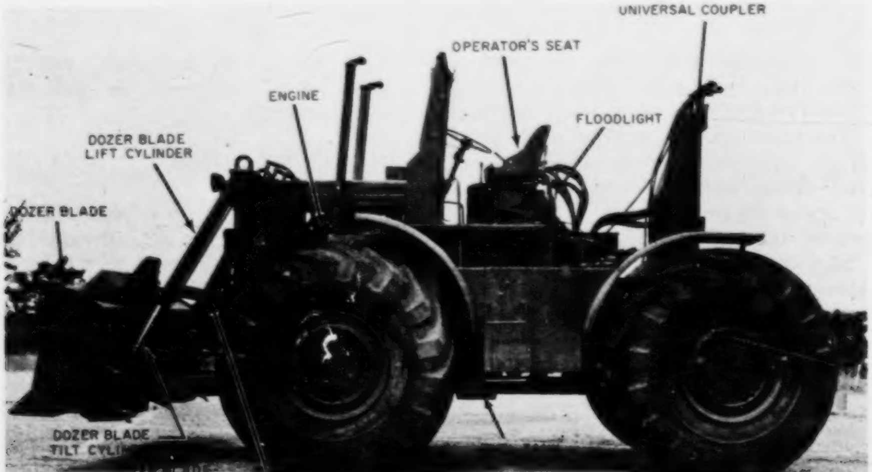

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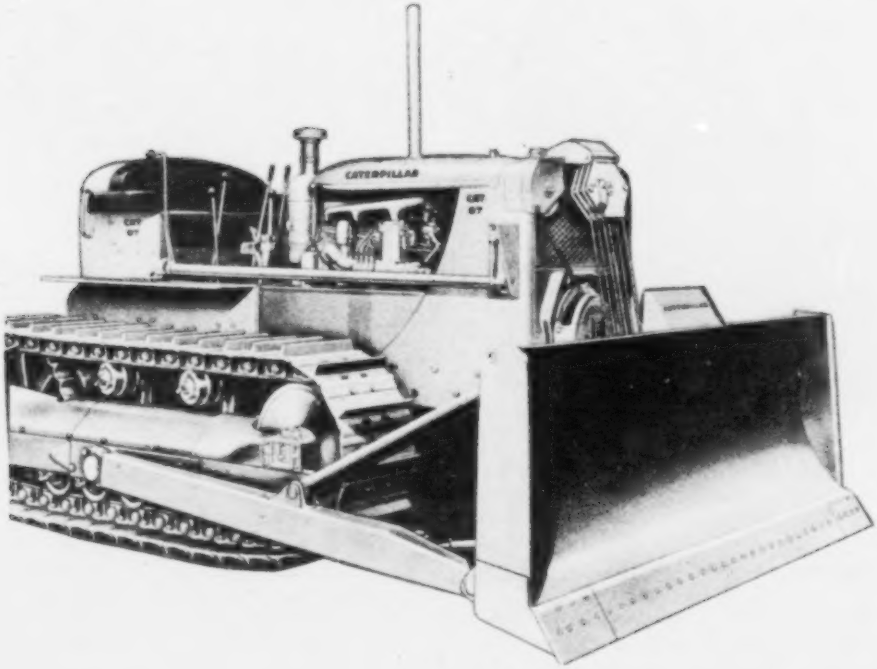
Figure 9-2. — M.R.S. model I-110 tractor with dozer blade.



29.62(115G)

Figure 9-3.—A typical straight dozer blade.

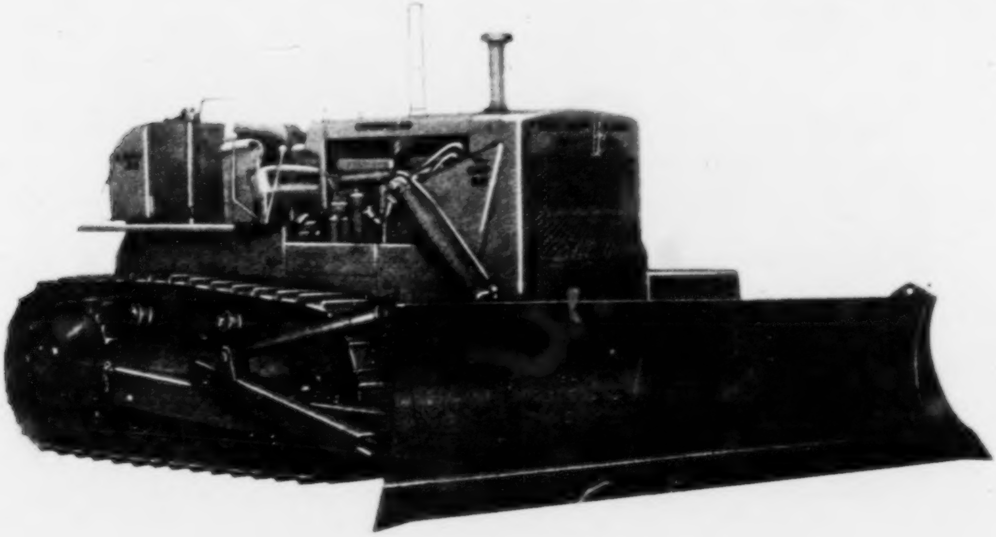
movers for scrapers and dump trailers on comparatively long hauls on good haul roads. They are also excellent prime movers for heavy equipment trailers or trailer-mounted equipment, such as crushing and screening plants. Some rubber-tired tractors are well adapted for use with dozer blades.

Rubber-tired tractors are designed for greater speed and mobility than crawler tractors, while providing almost as much power. Experience has found that rubber-tired tractors used in earthmoving operations can move materials more economically than either crawler tractors with scrapers or truck and shovel. This is particularly true where speed is the primary consideration on long hauls. Beside towing earthmoving scrapers, the rubber-tired tractor can, through the use of various mounted attachments, perform the same work as the crawler tractor in pioneer phases of construction. However, the rubber-tired tractor's capability to perform this type of work is limited by its traction and comparatively high bearing pressure. The use of the wide base, low pressure, and large diameter tires has improved but not eliminated these shortcomings.

TRACTOR BLADES

The most common type of tractor attachment is the DOZER BLADE, a heavy rectangular steel blade which is mounted on the front of the tractor and used for pushing earth either straight ahead (DRIFTING) or to one side (SIDE CASTING).

A tractor which is equipped with a dozer blade is called a DOZER or BULLDOZER. If the blade is one which can be used only at an angle of 90 degrees to the center axis of the tractor, the attachment is called a STRAIGHT DOZER BLADE. If the blade is one which can be ANGLED approximately 30 degrees to either side from its current 90 degree preposition, the attachment is called an ANGLEDOZER BLADE. A typical straight dozer blade is shown in figure 9-3, and an angledozer blade is shown in figure 9-4. The straight dozer blade is used mainly



115.449

Figure 9-4.—A typical angledozer blade.

for straight drifting, but can be used for side casting by making a series of pivoting passes with the tractor. The angledozer blade is used mainly for side casting.

Another tractor blade attachment which is used less frequently than those discussed above is the U-blade (fig. 9-5.) The U-blade has the sides advanced farther than the center. This makes it possible to transport a larger load by reducing side spill. The U-blade functions well in rough pioneering on sidehills and is ideal for stockpiling coal, sand, rock, and gravel.

RIPPER

Another type of tractor attachment is the ripper (fig. 9-6), which provides a powerful tool for breaking up material too compact to be broken by dozers, graders, and the like. The ripper is also used to uproot boulders and stumps; to loosen shale, sandstone, and asphalt pavement; and to rip up concrete slabs. After ripping these materials, easier and more efficient removal can be accomplished by supporting equipment.

A dozer blade may have ripper teeth hinged to the back of it in such a way that they float on the ground when the blade is moving forward, and dig in when the blade is moving backward.

WINCHES

Winches are mounted on tractor-dozer units (track and wheeled) or trucks. On a tractor-dozer unit, the winch is mounted in the rear and is directly geared to the rear power takeoff on the tractor, as illustrated in figure 9-7. This arrangement permits development of a line pull that is 50 to 100 percent greater than tractor pull. Tractor-mounted winches are used for uprooting trees and stumps, hoisting and skidding felled trees, and freeing mired equipment.

Some limitations encountered when using winches may be due to the limited pulling capacity and size of the tractor. The terrain may also affect maneuverability of the tractor.

SCRAPERS

Scrappers which are nonmotorized may be towed either by rubber-tired or crawler-type tractors. An example of a scraper towed by a crawler-type tractor is shown in figure 9-8. A scraper towed by a wheel-type tractor is shown in figure 9-9.

The crawler-type tractor is normally used for towing when large loads must be moved at

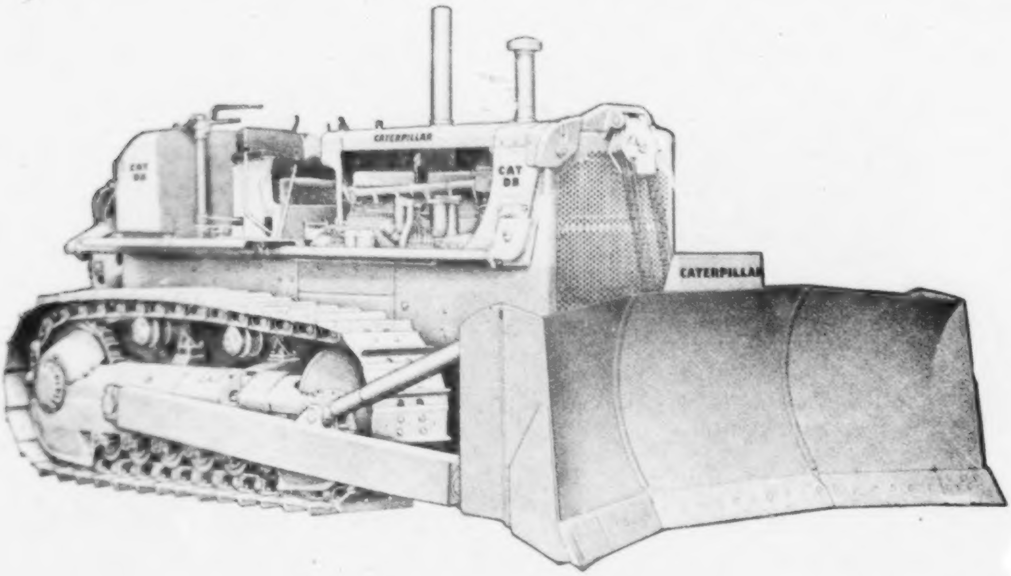
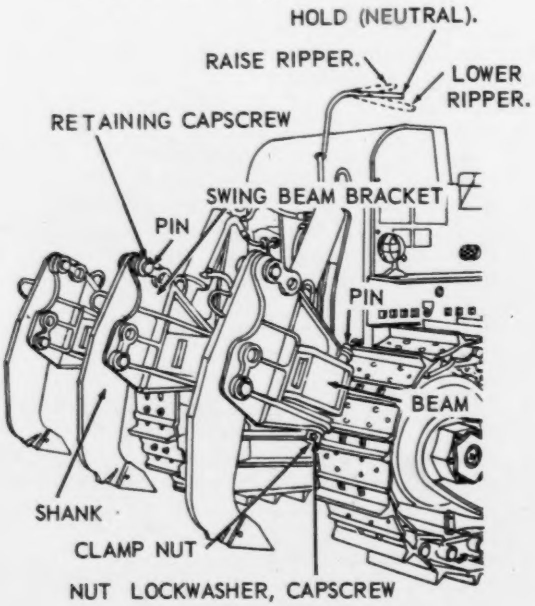
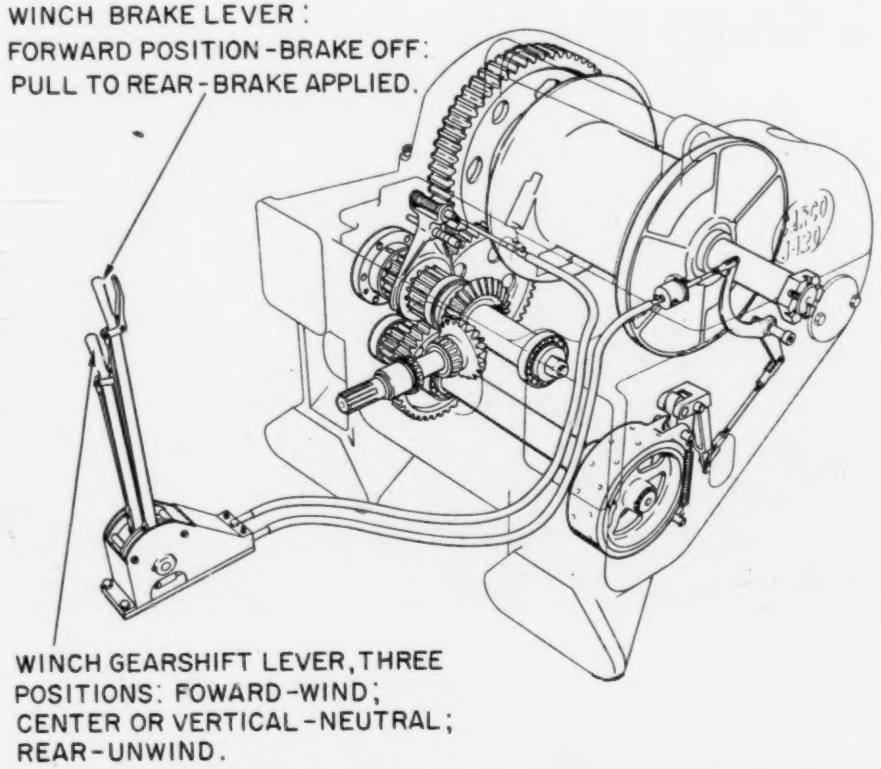


Figure 9-5.—A typical U-blade. 115.450



CAUTION: WHEN RAMS REACH THE END OF THEIR STROKE, RETURN THE CONTROL LEVER TO "HOLD" POSITION IMMEDIATELY.

Figure 9-6.—Ripper and control lever positions. 115.244


WINCH BRAKE LEVER:
FORWARD POSITION-BRAKE OFF:
PULL TO REAR-BRAKE APPLIED.
WINCH GEARSHIFT LEVER, THREE
POSITIONS: FOWARD-WIND;
CENTER OR VERTICAL-NEUTRAL;
REAR-UNWIND.

115.245

Figure 9-7.—Winch and winch control levers.

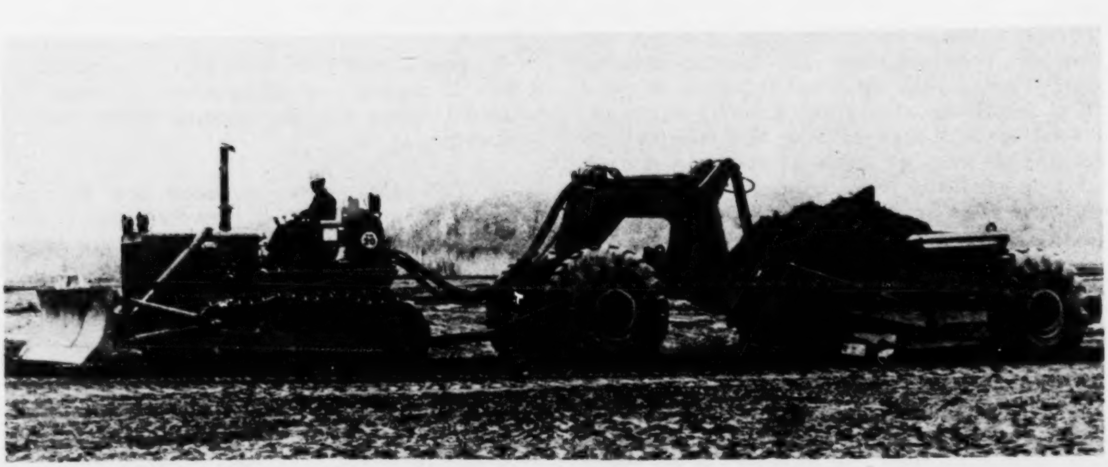


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Figure 9-8.—Crawler tractor drawn scraper.

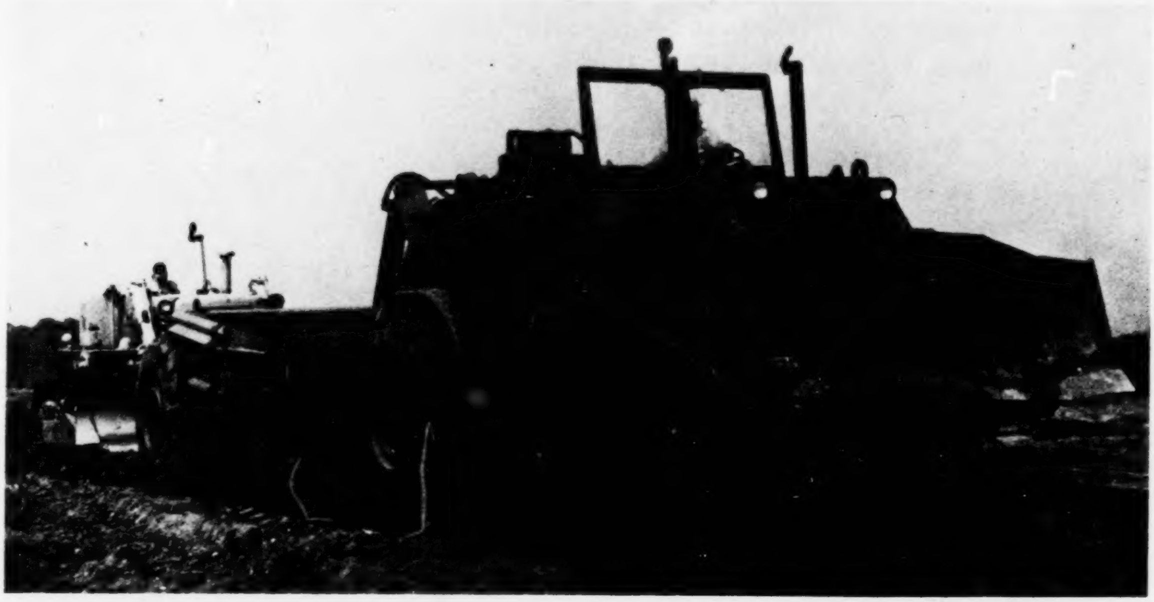

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Figure 9-9.—Four-wheel tractor pulling scraper.

rather slow speed because of steep grades, poor haul routes, or poor ground conditions.

Scrapers towed by crawler-type tractors are used for short to medium hauls ranging up to 1,500 feet.

Scrapers towed by wheel-type tractors are employed when maximum use can be made of tractor speed. This combination requires good hauling conditons, including grades, surfaces, and hauling distances of 900 to 5,000 feet, to develop high average rates of speed. A pusher tractor is generally required to assist the prime mover (crawler or wheel tractor) in loading the scraper. Your greatest utilization of scrapers will be in making cuts and in hauling material from the borrow pit to the fill area.

SIDE-BOOM CRANE

The side-boom crane attachment shown in figure 9-10 can be used for any type of general hoisting, but it is used most frequently on pipe-laying projects. This attachment is equipped with one winch for raising and lowering the boom and another for hoisting and lowering the hook-block assembly. To prevent the weight of heavy loads from tipping the tractor, counterweights are attached to the opposite side of the boom to counterbalance the loads being handled.

TOWED ROLLERS

A towed roller is one which is towed by either a crawler or rubber-tired tractor. The principal types are the tamping roller and the grid roller.

A TAMPING roller contains one or more cylindrical drums which revolve on a shaft mounted on a box-type towing frame. The towing frame is equipped with a towbar or tongue for hitching to the drawbar of the prime mover. Each drum is studded with projections, called feet, which usually run from 7 to 9 1/2 inches in length. Figure 9-11 shows a tamping roller with tapered feet, each of which has an enlarged, off-center sole, called a sheepsfoot.

Tamping rollers are used mainly for compacting loose fill other than sand, gravel, or crushed stone. On the first pass, the feet will gradually begin to "walk" themselves upward,

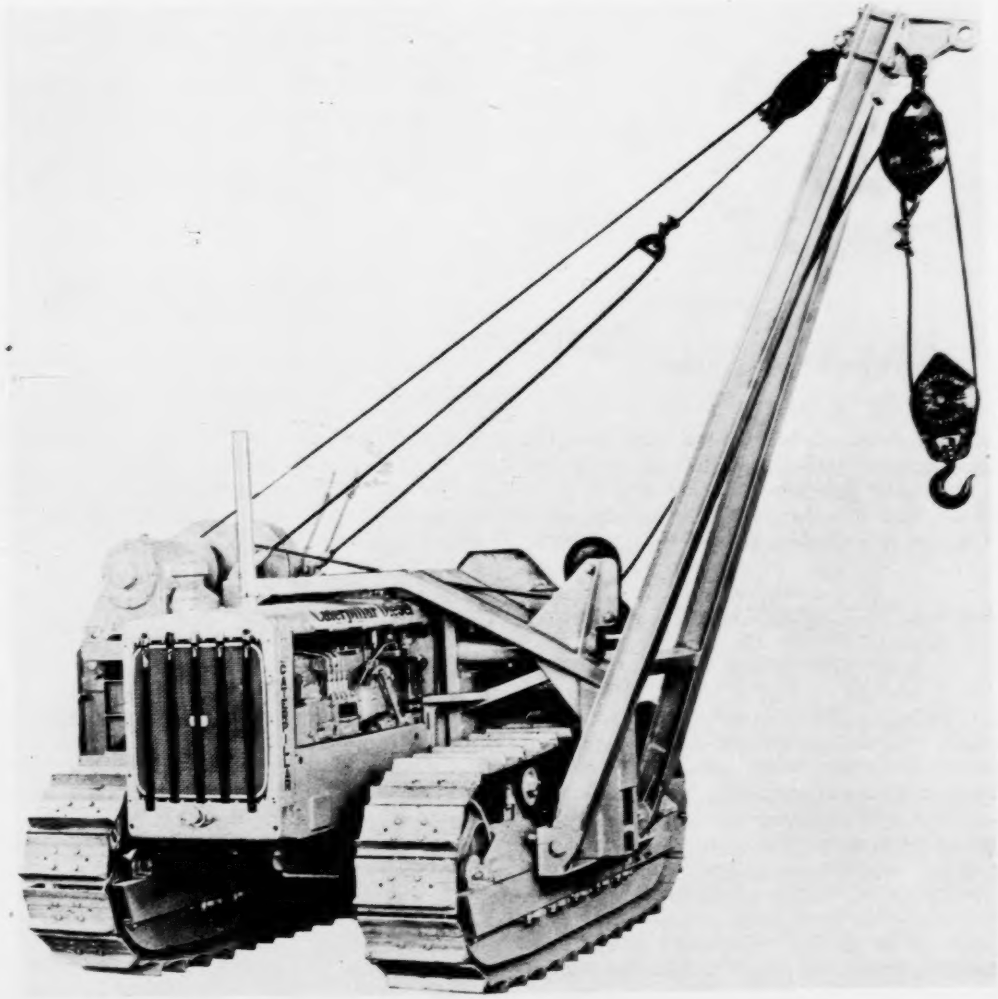

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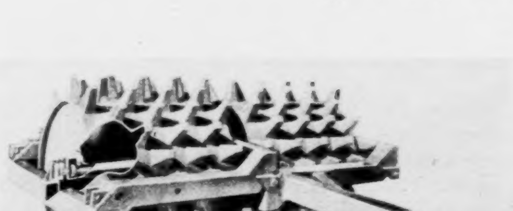
Figure 9-10.—Side-boom crane attachment.



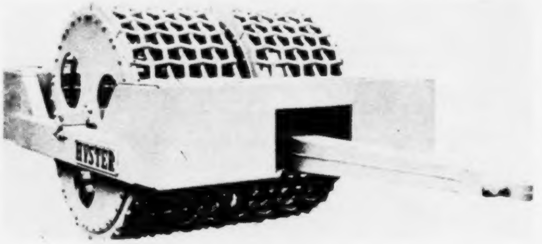
29.74

Figure 9-11.—Tamping roller.

until finally, when maximum compaction is attained, they will be almost entirely atop the ground.

Many tamping rollers can be ballasted for extra weight by filling the drum with sand or water. Some have containers for ballast mounted on the towing frame.

After ripping old bituminous material, GRID rollers (fig. 9-12) are used to break up and compact this material when it is to be used as a base course. They can also be used to crush such materials as sandstone, soft limestone,



81.312X

Figure 9-12.—Grid roller.

coral, and cinders. Grid rollers are mounted in towing frames similar to those on the towed roller previously described. They are usually heavily ballasted with large blocks of concrete, set in containers mounted on the towing frame.

CAPABILITIES, GROSS LIMITS, AND UTILIZATION OF TRACTORS AND ATTACHMENTS

Fundamental to most construction projects and certain ground maintenance jobs is the requirement to lower high ground areas and raise low ground areas to meet a common grade. Removal, disposal and/or placement of dirt, rock and impediments; treatment of earth fill; and numerous related operations are within the special province of earthmoving equipment designed to reduce the cost, time, and complications of this type of work. The following kinds of jobs are typical of tractor and attachment applications:

1. Clearing, stripping, pioneering, and ripping.
2. Short and long haul excavating and push loading.
3. Sloping, filling, backfilling, compacting, and finishing.

Dozers will handle all short-haul excavations up to 300 feet. For long-haul excavations over 300 feet, crawler or rubber-tired tractors and scrapers should be used.

The speed of clearing depends on the type of clearing, output of equipment, and methods used. Production rates of equipment under normal operating conditions are used for determining the total time required for the job. Knowing the area and type of clearing and the production rates of available equipment, the time can be estimated and a job schedule prepared.

The productive capacity of tractors and attachments, when used in construction and maintenance operation, is given in table 9-1, which serves as a guide only, and not as a table of production capacity to be expected on every job.

OPERATION OF TRACTORS AND ATTACHMENTS

The sole source of complete and authentic information on tractor and attachment operations is the operator's manual provided by the manufacturer of the tractor or attachment concerned.

The information given in this section describes the prestart checks, starting and operating procedures, during operations checks, and securing methods which are typical of tractors and attachments used by the Navy.

PRESTART CHECKS

The procedure for making prestart checks is similar with most types of tractors and attachments. However, the location of items to be checked differs from one type of tractor and attachment to another.

In making a prestart check of a CRAWLER TRACTOR equipped with a dozer blade of the type shown in figure 9-1, you should check the lubricating oil, radiator coolant, batteries, fuel, hydraulic oil, and rear frame oil.

Check the lubricating oil level with the bayonet gage provided. The level should be between the upper ("H") and lower ("L") marks on the "Engine Stopped" side of the bayonet gage. If it is necessary to bring the oil level up to the "H" mark on the gage, add a sufficient amount of the recommended type of lubricating oil.

Check the water level in the radiator. The correct level should be 1 inch above baffles; if below this level, add proper coolant.

After making sure the hydraulic dozer blade is resting level on the ground and the control handle is in the "Hold" position, remove the filler and level plug from the hydraulic reservoir located at the rear of the tractor. Check the level of hydraulic oil in the reservoir. If the oil level is low, add the specified type of hydraulic oil to bring the level up to the plug opening.

Table 9-1.—Productive Capacity of Tractors and Attachments

Equipment Used	Rate-Units Per Hour	Unit	Conditions
CLEARING AND GRUBBING			
Crawler Type Tractor with Dozer	0.25	Acre	Medium Clearing
Crawler Type Tractor with Dozer	1.00	Acre	Light Stripping
EXCAVATION			
Crawler Type Tractor with Dozer	44	Cu Yd	300 feet level haul
Crawler Type Tractor with Angledozer	86	Cu Yd	Sidehill Cut 50 feet Common Earth
Rubber-Tired Tractor with Dozer	66	Cu Yd	300 feet level haul
Crawler Type Tractor with Scraper 12 cu yd	74	Cu Yd	1,000 feet level haul
Rubber-Tired Tractor with Scraper 12 cu yd	120	Cu Yd	1,000 feet level haul
EMBANKMENT			
Crawler Type Tractor with Angledozer	300	Cu Yd	Spreading Material
Crawler Type Tractor with Towed Roller (sheepsfoot)	250	Cu Yd	9-inch layers, 8 passes
SUBGRADE PREPARATION			
Crawler Type Tractor with Towed Roller (sheepsfoot)	650	Sq Yd	6-inch layers, 8 passes
BASE COURSE CONSTRUCTION			
Crawler Type Tractor with Angledozer	300	Cu Yd	Spread Material

115.451

CAUTION: Always loosen the filler and level plug slowly, in case there is still some pressure in the system.

Check the water level in the batteries. You will find four 6-volt negative-grounded batteries connected in series, two mounted under the operator's seat and two mounted to the left of the operator's seat.

Now open the fuel tank drain valve, located at the bottom of the tractor fuel tank, to allow moisture to drain from the tank prior to starting.

As you continue, check the rear frame oil level. The rear frame oil level gage and filler pipe are located to the left of the operator's seat. The level should be at the upper ("FULL") mark on the "Engine Stopped" side of the bayonet gage. If it is necessary to bring the oil level up to the "FULL" mark on the gage, add a sufficient amount of the specified type of oil.

Note: Never operate the tractor if the level of the oil is at or below the "LOW" mark on the rear frame oil level gage.

Check the tractor headlights, panel lights, and rear lights by turning on the light switch and observing whether the lights are burning. Have someone observe the rear lights.

In making a prestart check of the RUBBER-TIRED TRACTOR equipped with a dozer blade of the type shown in figure 9-2, check the lubricating oil, radiator coolant, batteries, fuel, hydraulic oil, and air cleaner filter.

Check the lubricating oil level with the dipstick provided. The level should be at the "FULL" mark on the dipstick. If it is necessary to bring the oil level up to the "FULL" mark on the dipstick, add a sufficient amount of the recommended type of lubricating oil. The dipstick is located on the left side of the tractor engine.

Check the water level in the radiator. The correct level should be 1 inch above the baffles; if below this level, add proper coolant.

After making sure the hydraulic dozer blade is resting level on the ground and the control handle is in the "HOLD" position, remove the filler cap and dipstick from the hydraulic reservoir located on the right side of the operator's compartment. Check the level of the hydraulic oil in the reservoir. If necessary add the specified type of hydraulic oil to bring the level up to the "FULL" mark on the dipstick.

Check the water level in the batteries. You will find two 12-volt negative-grounded batteries connected in series and mounted on the right side of the tractor behind the hydraulic reservoir.

Inspect the air cleaner filler cartridge. Clean or replace, as required. The air cleaner is located on the right side rear of the engine compartment.

Now drain approximately 4 ounces of fuel from the fuel strainer and a similar amount from the fuel filter through the drain cocks provided for this purpose. The filter and strainer are located on the front right side of the engine.

Check the fuel in the fuel tank. See that the tank is full and the vent is open. The fuel tank is located on the left side of the operator's compartment.

When checking the wheels, tires, and horn on the rubber-tired tractor, follow the procedures described for equipment in previous chapters of this manual.

STARTING CHECKS

After starting the engine, but before putting a tractor into operation, a few additional checks are necessary. Major items to be covered in a starting check of the CRAWLER and RUBBER-TIRED TRACTOR are given below.

Crawler Tractor

The crawler tractor ammeter indicator should register a positive charge reading within the "RUN" range when the engine is operating faster than low idle speed.

The engine oil indicator should register in the "IDLE" range immediately upon starting. When full engine load speed is applied, it should register in the "RUN" range. If little or no pressure is indicated, stop the engine and notify the maintenance shop.

Observe the engine coolant heat indicator. The pointer of the indicator should register in the "RUN" range after the engine has operated a sufficient length of time and should remain there during regular operation.

Check the transmission clutch oil pressure indicator, which should register in the "RUN" range. If the gage indicates in the "CHANGE FILTER" range, stop the engine and service the suction and pressure filters.

Observe the transmission lubricating oil pressure indicator. The indicator should register in the "RUN" (green) range. If the indicator pointer moves into either of the red ranges, stop the engine and service the suction oil filter.

Check the torque converter oil temperature indicator. The pointer of the indicator must register in the "RUN" range (green area) after the engine has operated a sufficient length of time. If the indicator registers in the "CHECK" range, make the following checks:

1. Be sure the transmission clutch oil pressure indicator is registering in the correct range.
2. Stop the engine. Check the oil level in the rear frame as indicated in the prestart section of this chapter.
3. Be sure the transmission oil cooler (mounted on the front of the radiator) is not restricted.
4. Service the transmission and torque converter filters in the following sequence: pressure filter, safety filter, and then the suction filter.

Rubber-Tired Tractor

The rubber-tired tractor ammeter should show a reading in the charge range whenever the engine is running at medium speed. If the ammeter registers well into the discharge range during engine operation, the batteries are not receiving the correct charging current. Stop the engine and investigate the cause of the malfunction.

The engine coolant temperature gage should range between 160° to 185°F under normal operating conditions.

NOTE: A warning buzzer sounds when coolant reaches 210°F.

As you check your instruments further, observe the engine oil pressure gage. As the engine warms up at idling speed, the oil pressure should read between 30 and 60 psi on the gage. When registering lower than the prescribed pressures or if no oil pressure is indicated on the gage, stop the engine and notify the maintenance shop.

Check the transmission oil temperature indicator. The temperature should not exceed 250°F. If the temperature rises above 250°F, stop the tractor immediately and check the transmission for external oil leaks, pinched or obstructed lines. If no leaks or obstructions are evident, operate the engine at full rpm. The temperature should drop in about 15 seconds. If the temperature does not drop, stop the engine and notify the maintenance shop.

NOTE: A warning buzzer will sound when the temperature exceeds limits.

Check the transmission oil pressure gage for a constant reading between 110 to 120 psi on the gage. Erratic reading indicates low oil level or other trouble. If the oil is at proper level and pressure still remains erratic, stop the engine and notify the maintenance shop.

NOTE: A warning buzzer will sound when pressure exceeds limits.

Now check the air pressure gage. The brake air pressure system gage should always read in excess of 60 psi while the engine is running at fast idling speed or full governed speed. If pressure remains low, check the airbrake system for trouble such as air line leaks, broken air lines, or air reservoir drain cocks open. DO NOT operate any equipment with low brake air pressure. Notify the mechanics immediately.

DURING OPERATION CHECKS

Although all indicators on the tractor can be registering within the specified range during operation, there are additional symptoms by which a malfunction can be identified. Symptoms in addition to those discussed in chapter 5 of this manual are given below.

Steering Trouble

Besides your eyes, ears, and nose, your sense of touch will relay symptoms of mechanical failure to you. For instances, if you are operating a rubber-tired tractor, your hands on the steering wheel will tell you if the machine pulls to the right or left when the brakes are applied. When you feel the tractor pull to one side, stop and check the tires. Your hands on the wheel will also tell you if the tractor turns hard and if play in the steering wheel is excessive. You will also feel vibrations caused by unbalanced wheels.

When a crawler tractor is equipped with steering clutches, these clutches should engage and disengage positively.

Brakes

When the pivot brakes on the crawler tractor are too tight, this condition will cause the tractor to creep to one side. When this happens,

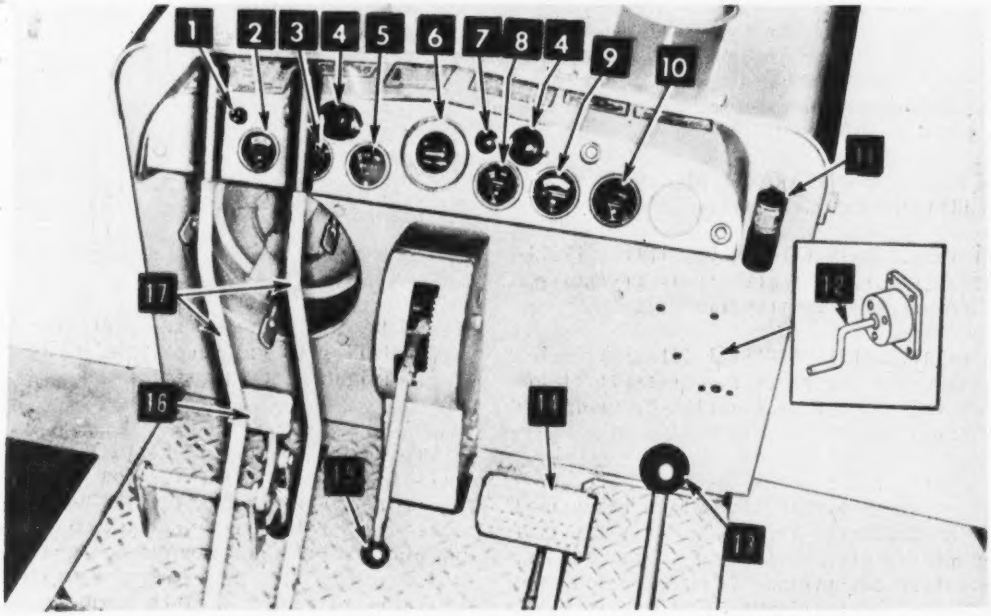


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Figure 9-13. — Indicators and controls, TD-20B series.

adjustment is needed. Let the mechanic perform the necessary adjustment. After adjustments have been made, the tractor must be checked out in actual operation for proper functioning.

Clutches

If the tractor is equipped with a hand-operated master clutch lever, this lever should engage with a distinct snap over center. If this is not the case, a clutch adjustment must be made.

OPERATING CRAWLER TRACTOR

The safe and efficient use of a crawler tractor requires skill and alertness on the part of the operator. For earthmoving operations, the crawler tractor is especially suited for sidehill excavations and where maximum power is required at relatively slow rates of speed.

Let's take a look at one particular model of crawler tractor to familiarize you with the instruments and controls, as well as operational capabilities. The information given is on the International Harvester TD-20B series crawler tractor, and applies ONLY to this machine. This information will give you an idea of how one of the several types of crawler tractors used by the Naval Construction Force is operated.

Before operating the crawler tractor, you should first become familiar with its different indicators and controls (fig. 9-13). The purpose of the various indicators and controls is explained below; the numbers in parentheses correspond to those used in figure 9-13 to indicate the location of indicators or controls.

The FUSE HOUSING (1) protects the panel lights, head lights, and rear lights.

The TORQUE CONVERTER OIL TEMPERATURE INDICATOR (2) registers the temperature of the fluid in the torque converter.

The AMMETER (3) indicates the rate at which the battery is being charged or discharged.

An ENGINE COOLANT HEAT INDICATOR (5) shows the temperature of the coolant circulating through the engine.

An ENGINE HOUR METER (6) records the actual hours of engine operation. It eliminates guesswork when determining proper lubrication and maintenance periods.

An ENGINE OIL PRESSURE INDICATOR (8) shows the pressure at which the lubricating oil is circulating through the engine.

A TRANSMISSION LUBRICATING OIL PRESSURE INDICATOR (9) registers the pressure of the lubricating oil in the transmission.

A TRANSMISSION CLUTCH OIL PRESSURE INDICATOR (10) registers the pressure of the oil being delivered to the clutch packs in the transmission.

The AIR CLEANER SERVICE INDICATOR (11) has a green signal band which telescopes a red signal band when a pressure drop (vacuum) between the air cleaner and the engine occurs. After starting the engine the green band may rise sufficiently, exposing part of the red band. (THIS MUST NOT BE MISTAKEN AS A SIGNAL FOR ELEMENT SERVICE.) During operation, the green band will gradually rise in the window as dirt accumulates in the filter element. When the filter element reaches the maximum allowable restriction, the green band is out of view and automatically locks in this position. (The red band will remain fully exposed even after stopping the engine. When this happens, filter element service is required.) After servicing the element, reset the indicator by pressing the reset button.

The RADIATOR SHUTTER CONTROL HANDLE (12) controls the movement of the radiator shutter. Turn the handle to the right to open the shutter, and to the left to close it.

The TRANSMISSION "HI-LO" SHIFT LEVER (13) is used to select the "HI" or the "LO" transmission gear range to provide two speeds forward and two reverse.

The BRAKE PEDAL (14) is used to stop the tractor by mechanically applying the pivot brakes. The brake pedal is also used as a parking brake.

The ENGINE SPEED CONTROL LEVER (15) is used to increase the engine speed by pulling the lever "up;" pushing the lever "down" decreases the speed. When you move this lever all the way down, it cuts off the fuel supply which stops the engine.

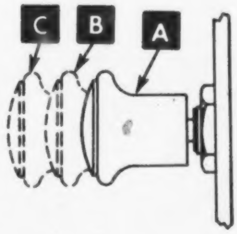

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Figure 9-14.—Light switch positions: (A) Off. (B) Headlights and panel lights. (C) Headlights, panel lights, and rear lights.

Depressing the DECELERATOR PEDAL (16) slows the engine and overrides the setting of the engine speed control lever. The decelerator pedal will slow the engine speed to approximately low idle so that the transmission gears can be shifted easily and the tractor can be started in motion gradually, with the engine speed lever remaining in its original position.

The right- and left-hand STEERING LEVERS (17) are used to steer the tractor by engaging or disengaging the power flow from the transmission to either track.

The instrument panel lights are operated by the LIGHT SWITCH (7). The light switch has three positions, as shown in figure 9-14.

The STARTING SWITCH BUTTON is shown in view A, figure 9-15. To crank the engine, press the button to complete the electrical circuit between the batteries and the cranking motor.

The ELECTRICAL SYSTEM MASTER SWITCH illustrated in view B, figure 9-15 must be pulled and turned to either "OFF" position to cut-out the electrical system, or to the "ON" position to close the electrical system. (NOTE: Keep switch ON while the engine is running.)

The BRAKE PEDAL LOCK is shown in view C, figure 9-15. To lock the brake pedal, depress the pedal as far as possible and lift up on the lock lever as shown in figure 9-16; then remove your foot from the brake pedal, and the lock will hold the pedal in the locked position. To release the footbrake, depress the pedal and the lock will automatically disengage.

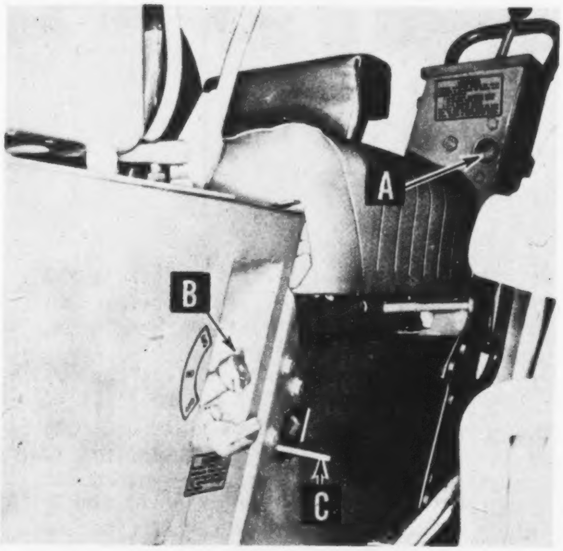

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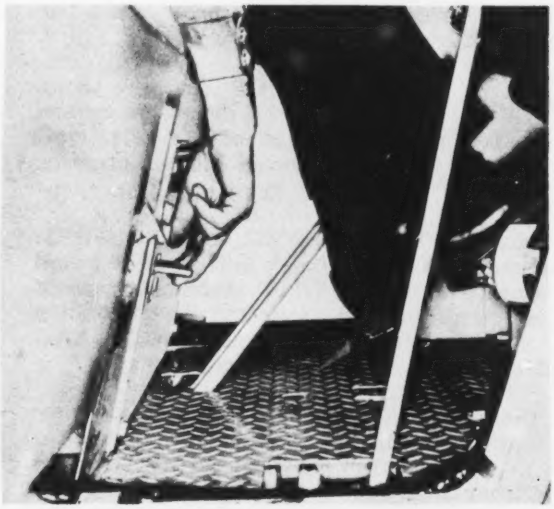
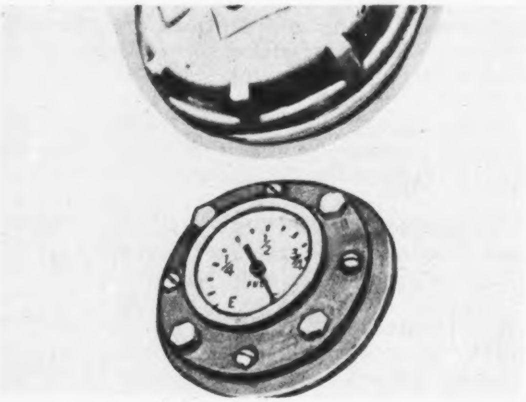
Figure 9-15.—(A) Starting switch button. (B) Electrical system master switch. (C) Brake pedal lock.



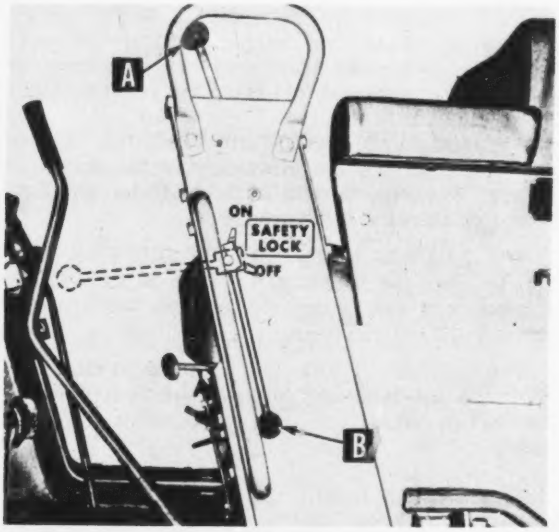
115.254
Figure 9-16.—Engaging the brake pedal lock.



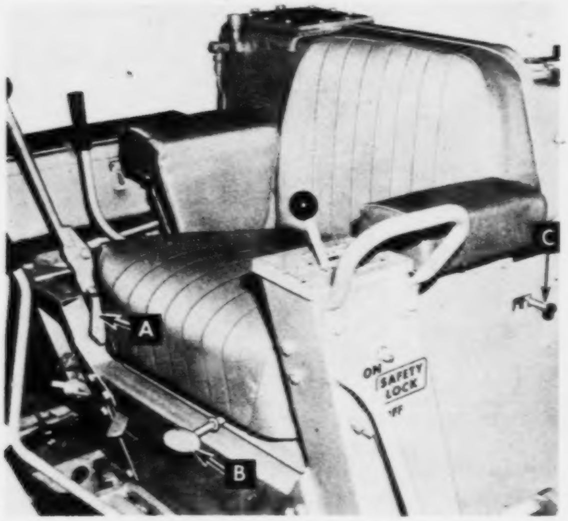
115.255
Figure 9-17.—Fuel tank level gage.

A FUEL TANK LEVEL GAGE, shown in figure 9-17, is located on top of the 86-gallon, fuel tank and registers the amount of fuel.

The TRANSMISSION GEAR SELECTOR LEVER, shown in view A, figure 9-18, is used to select the various transmission gear ranges.



115.256
Figure 9-18.—(A) Transmission gear selector lever, (B) Selector lock lever.



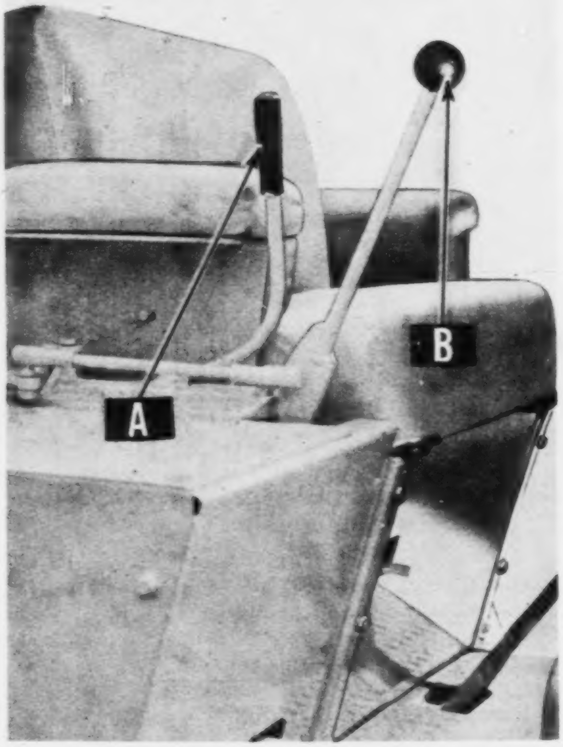
115.257
Figure 9-19. — Seat adjustment.

The TRANSMISSION SELECTOR LOCK LEVER, shown in view B, figure 9-18, is used to lock the transmission gear selector lever in the NEUTRAL position.

The SEAT ADJUSTMENT, illustrated in figure 9-19, is accomplished by pressing down on lever (A), and sliding the seat back and forth to any one of five positions. When the seat engages the slide rail notch in the desired position, release the lever. Turn knob (B) to raise or lower the bottom seat cushion to any one of the four positions provided. Pull up on the adjuster rod (C), one on each side, and move the back seat cushion to any one of three positions.

When pulled toward the operator, the AUXILIARY CONTROL LEVER (A), figure 9-20, engages the hydraulic valve for engaging dozer blade operation. Pushing the lever away from the operator engages the hydraulic valve for engaging scraper operation control levers.

The HYDRAULIC CONTROL LEVER (B), figure 9-20, controls the dozer blade operation. Pull the control lever toward you for left-hand blade tilt; push the control lever away from you for right-hand blade tilt; release the lever and it returns to "hold" position. The lever is pulled back to raise the dozer blade and pushed forward the lower the blade. To place the dozer blade in "float" position, the lever is pushed forward as far as it will travel.



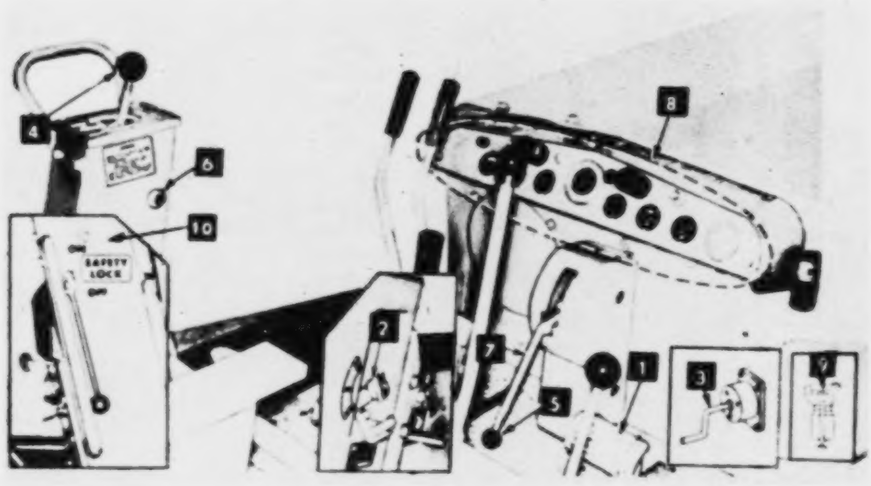
115.258
Figure 9-20. — Hydraulic valve control levers.

Starting The Engine

The numbers in parentheses below correspond to those numbers listed in figure 9-21 showing the starting sequence of the TD-20B series crawler tractor engine.

Apply and lock the footbrake (1) and turn the electrical system master switch (2) to the ON position.

Now turn the radiator shutter handle (3) clockwise to open the shutter; counterclockwise to close it. Once the engine is warm, regulate



115.259

Figure 9-21.—Starting the engine.

the shutter as required to hold the needle of the engine coolant heat indicator in the center of the RUN range. The shutter must be left open in warm weather operation.

Lock the power shift transmission gear selector lever (4) in NEUTRAL by engaging the transmission selector lock lever to the ON position (10).

Move the engine speed control lever (5) all the way up, then return to half throttle (approximately fourth notch from bottom).

Crank engine as follows:

a. NORMAL START—Press the starting switch button (6).
b. COLD WEATHER START—Press the starting switch button (6), and simultaneously depress the injector lever (9). After starting, release injector lever.

After the engine starts, reduce engine speed to approximately 800 rpm (first or second notch (7).) Then check all indicators (8) for proper engine operation prior to operation of the crawler tractor.

NOTE: Crank the engine for 30 seconds at a time; if it does not start, allow the cranking motor to cool for 2 to 3 minutes before cranking again.

This engine cannot be started by towing, pushing, or coasting the tractor.

Steps For Operating

The numbers in parentheses below correspond to those in figure 9-22 showing the operating steps for the TD-20B series crawler tractor.

Place the engine speed control lever (1) in the high position.

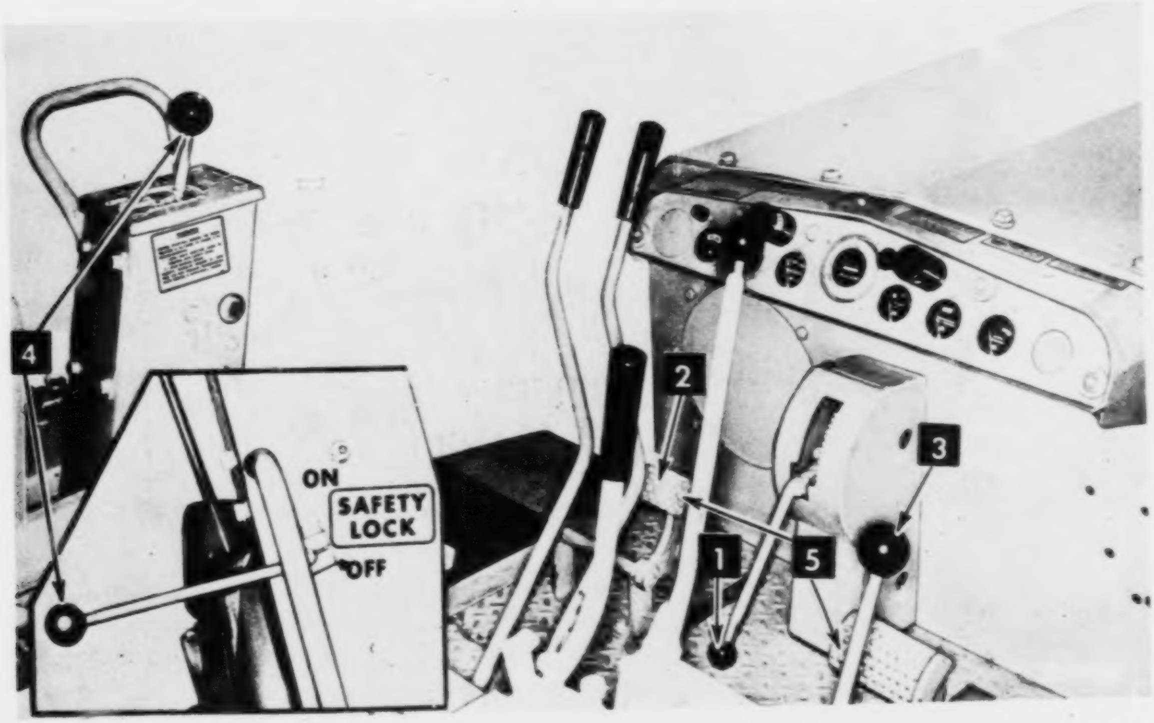
Depress the decelerator pedal (2) to decrease engine speed to low idle.

Shift the HI-LO shift lever (3) from neutral (N) to the desired position.

Unlock the gear selector lever (4) and move it to the desired position.

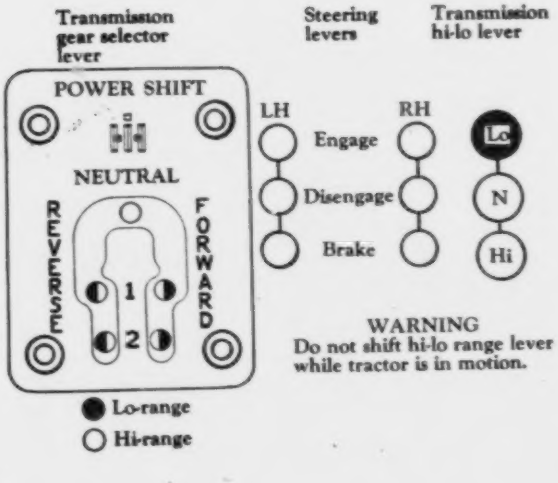
Release the brake pedal (5) and gradually release the decelerator pedal (2).

Steering the tractor is accomplished by two steering levers; each lever functions in three positions as shown in figure 9-23. To turn to the right or left, pull the steering lever back on the side toward which the turn is desired. Pull the lever back just enough to make the desired turn. To make a pivot turn, pull the lever all the way back. When both steering levers are simultaneously pulled all the way back, the braking action "locks" both tracks.



115.260

Figure 9-22. — Operating the tractor.



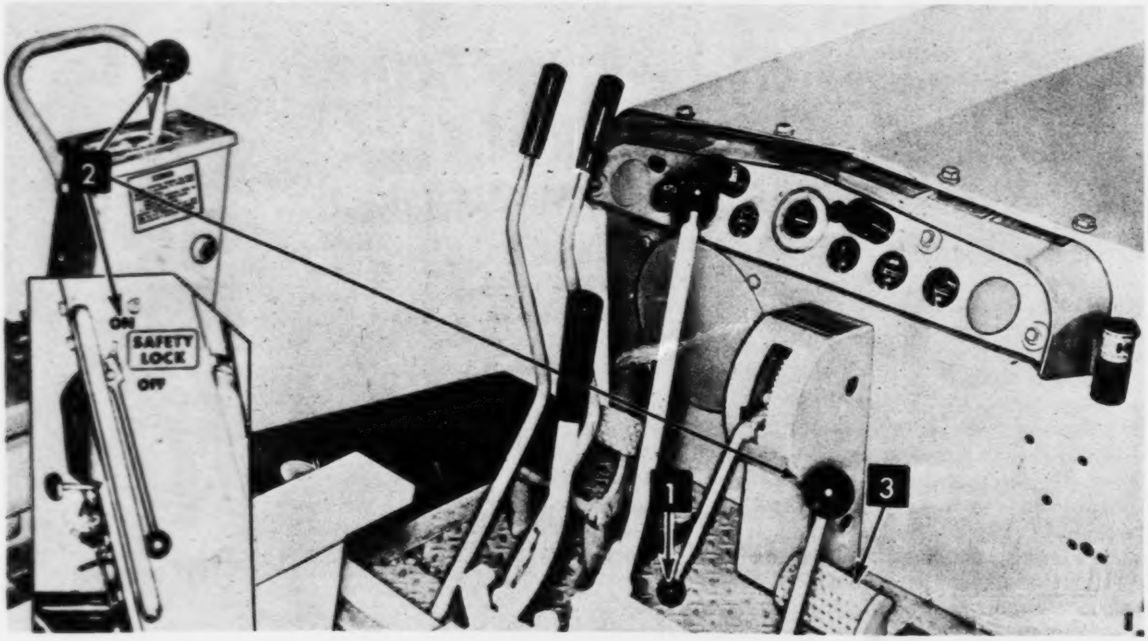
115.261

Figure 9-23. — Shifting patterns.

NOTE: Never pull both steering levers all the way back to stop the tractor unless the tractor is moving very slowly. Use the footbrake to slow or stop the tractor.

The transmission has a LO speed range for heavy work, and a HI speed range for normal work and traveling. Remember: selecting the proper HI or LO speed range will depend upon ground conditions and the type of material being handled. Before shifting to either HI or LO speed range, the transmission gear selector lever must be in neutral.

To shift the transmission gear selector lever within the HI or LO speed ranges, the tractor must be stopped. There are two power shift speed ranges, "1" and "2", as shown in figure 9-22. These speeds are available in both forward and reverse, and are power shifted with the gear selector lever. To operate in either HI or LO range, place the gear selector in range "1." If you want an "on-the-go" increase in tractor



115.262

Figure 9-24. — Stopping the tractor.

speed, move the selector lever to range "2." When operating in range "2," and you want an "on-the-go" track power increase, shift the selector lever into range "1."

Stopping The Tractor

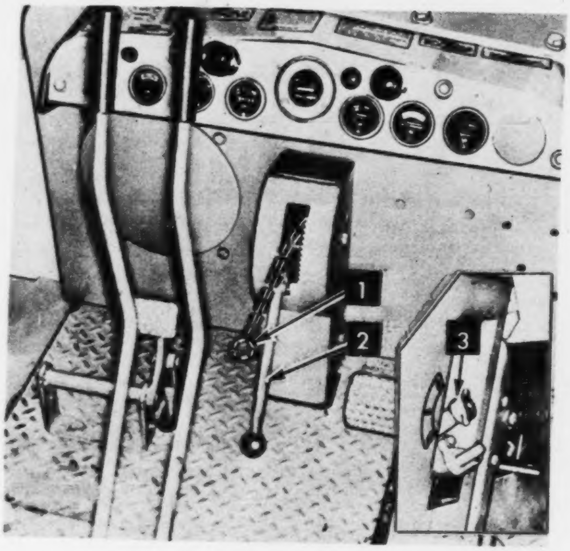
The numbers below correspond to those in figure 9-24 showing the sequence in stopping the TD-20B series crawler tractor.

Set the engine speed control lever (1), down to idle speed; DO NOT STOP THE ENGINE. Then place and lock the transmission gear selector lever in neutral and place the "HI-LO" shift lever (2) in neutral. As the last step, place foot on brake (3) and lock.

Stopping The Engine

The numbers below correspond to those in figure 9-25 showing the sequence in stopping the engine of the TD-20B series crawler tractor.

Operate the engine at low idle (1) for 3 to 5 minutes.



115.263

Figure 9-25. — Stopping the engine.

NOTE: Serious damage can result to the engine and turbocharger if the above step is neglected.

Move the engine speed control lever (2) down to the shut-off position.

Turn the electrical system master switch (3) to the "OFF" position.

Operation Capabilities

In operating the tractor, start all jobs, when possible, from relatively level ground. If necessary, level an area large enough to provide sufficient working space for the tractor. This prevents back-and-forth pitching of the tractor and will result in easier digging.

Avoid track spinning whenever possible; this wastes effort and only converts a relatively smooth working area into ruts and piles of material that pitch and tilt a tractor. In cold weather this material will freeze and cause additional difficulty the following work day.

Crossing ditches, ridges, rocks, or logs should be done slowly and, if possible, at an angle. This procedure slows the fall, lessens the danger of upsetting the tractor, and reduces the fall jolt which can be harmful to both the operator and tractor.

Always feed the blade into the ground gradually until the desired depth of the cut is obtained. When selecting the gear range and determining the depth of the cut, allow for an increase in resistance as the load increases. When raising the blade at the end of a cut, do so gradually to avoid an abrupt ridge or bump in the path of the tractor. Move your material down-grade whenever possible to gain reduced effort.

A sidehill cut can be started easier if a small bench cut is first made as shown in figure 9-26. Then, when digging, as in figure 9-27, keep the inside (uphill) surface slightly lower to gain greater tractor stability. Tilting the blade will provide this type of cut with little effort on the part of the operator. Always cut the shelf wide enough to provide solid support for equipment that will be using it later. If possible, move the material downhill to gain the advantage of gravity, reduced effort, and increased tractor stability. In addition to the method described above, side casting of material can be employed as well.

Soft soil or shallow slopes may allow the sidehill cut to be made as shown in figure 9-28. Increased stability is realized by running the

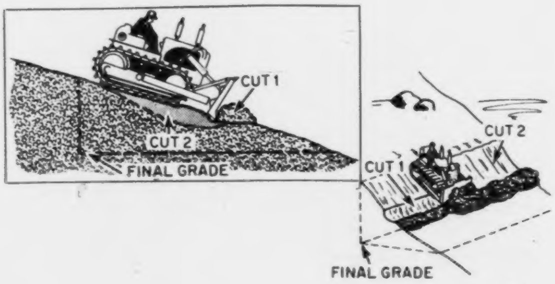


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Figure 9-26.—Bench cut.

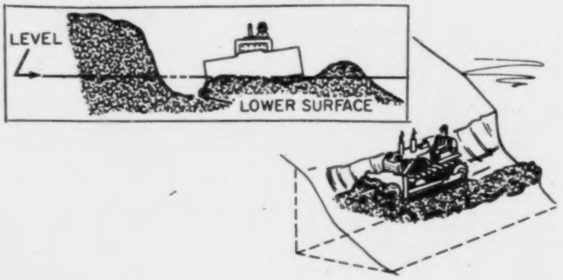

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Figure 9-27.—Sidehill cut.

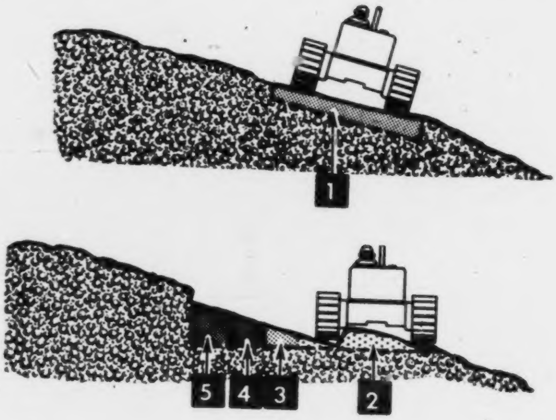

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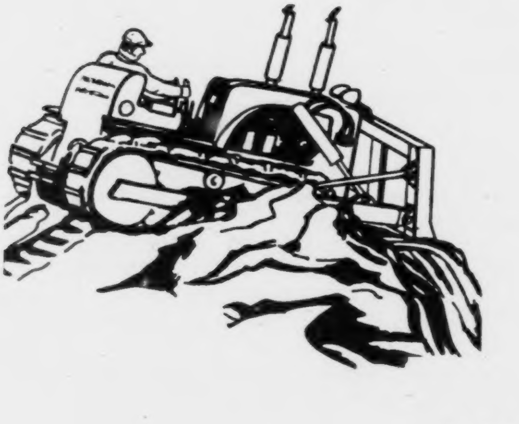
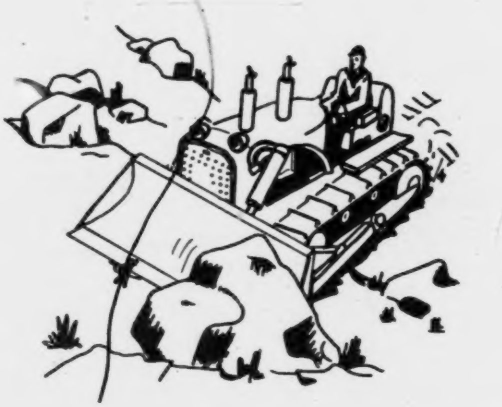
Figure 9-28.—Shallow slopes.



115.267
Figure 9-29.—Drifting material over embankment.



115.268
Figure 9-30.—Removing rock.

uphill track inside the ridge left by the first cut. Cuts 3, 4, and 5 illustrate the completion of the shelf. Once again, pushing the loosened material to the lower side of the slope will normally reduce time. Do not push material beyond the point required to retain firm track support as shown in figure 9-29. When backing up, do not raise the blade as this puts extra weight on the front idlers, thus causing greater track penetration. Let the blade float as you back away from the edge of soft fills.

When clearing a rocky area, remove the small and loose rocks first; then large and solid rocks can be loosened and moved with less difficulty. When loosening large solid rocks, tilt the blade and pry under the rock with the lower edge of the blade. Lifting rock with the blade while pushing will increase traction and reduce track spinning. Figure 9-30 shows the proper positioning of the blade for removing rocks. (After working in rock, check cutting edges, end bits, and bowl face for damage.)

When using your tractor as a pusher, aiding scraper operation as shown in figure 9-31, be sure you control your tractor. Excessive "push" effort can cause the scraper unit to "jackknife," resulting in injury to you or damage to the scraper. On turns, be sure the blade of your tractor does not cut the rear tires of the scraper, resulting in downtime and costly tire replacement.

Bulldozers are ideal for spreading fill material brought in by trucks or dump wagons. Your blade should be kept in a straight positon so the material is drifted directly under the cutting edge. Figure 9-32 illustrates this procedure.

When finishing in non-solid materials, such as earth, drag your blade backwards as shown in figure 9-33 for a smooth job. Rock, of course, may damage the blade base; therefore, dragging your blade backwards is not recommended where abrasive material is being placed.

Angling your blade is ideal for widening fills. Travel a foot or so from the slope side of the fill, allowing the material to spill off your blade and over the side of the slope, as illustrated in figure 9-34.

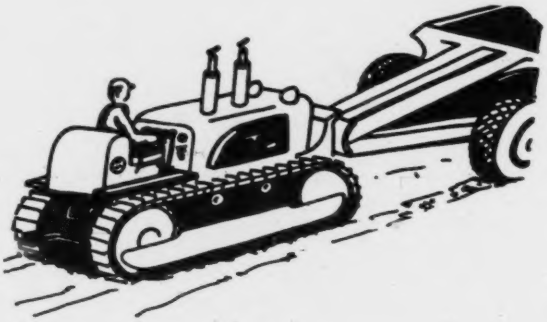


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Figure 9-31.—Pusher.

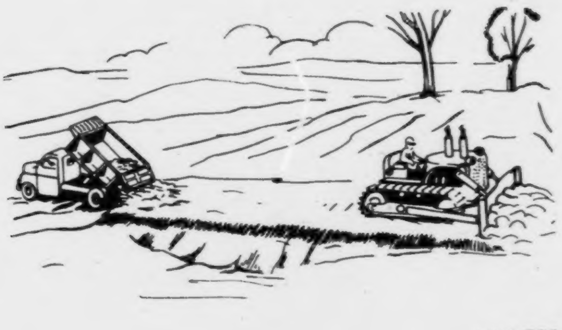

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Figure 9-32.—Spreading material.

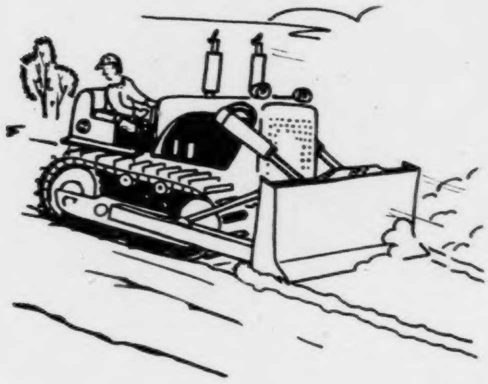

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Figure 9-33.—Finishing (back drag).

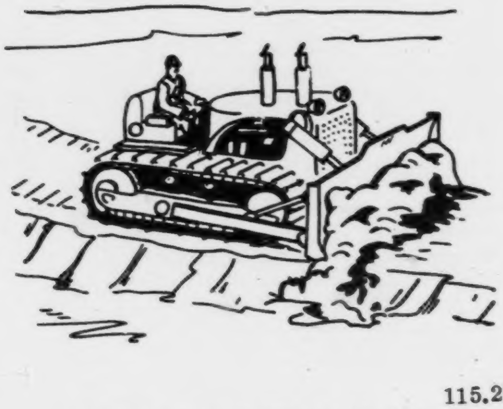

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Figure 9-34.—Spilling material.

OPERATION OF RUBBER-TIRED TRACTOR

In the preceding section, we discussed the International Harvester TD-20B series crawler tractor. Now let's turn our attention to the M.R.S. model I-110 rubber-tired tractor. The information presented will give you an idea of how one type of rubber-tired tractor used by the Navy is operated.

Before operating the rubber-tired tractor, you should first become familiar with its controls and different instruments (fig. 9-35). The purpose of some of the individual controls and instruments is explained below; the numbers in parentheses correspond to those used in figure 9-35 to indicate the location of controls and instruments.

The AMMETER (1) is mounted at the top left hand side of the instrument panel. It indicates the charge and discharge rate of the battery.

The ENGINE SHUTDOWN CABLE (2) is located on the left-hand side of the control panel to the left of the steering column. This cable, when pulled, will place the fuel injector rack in the "no fuel" position.

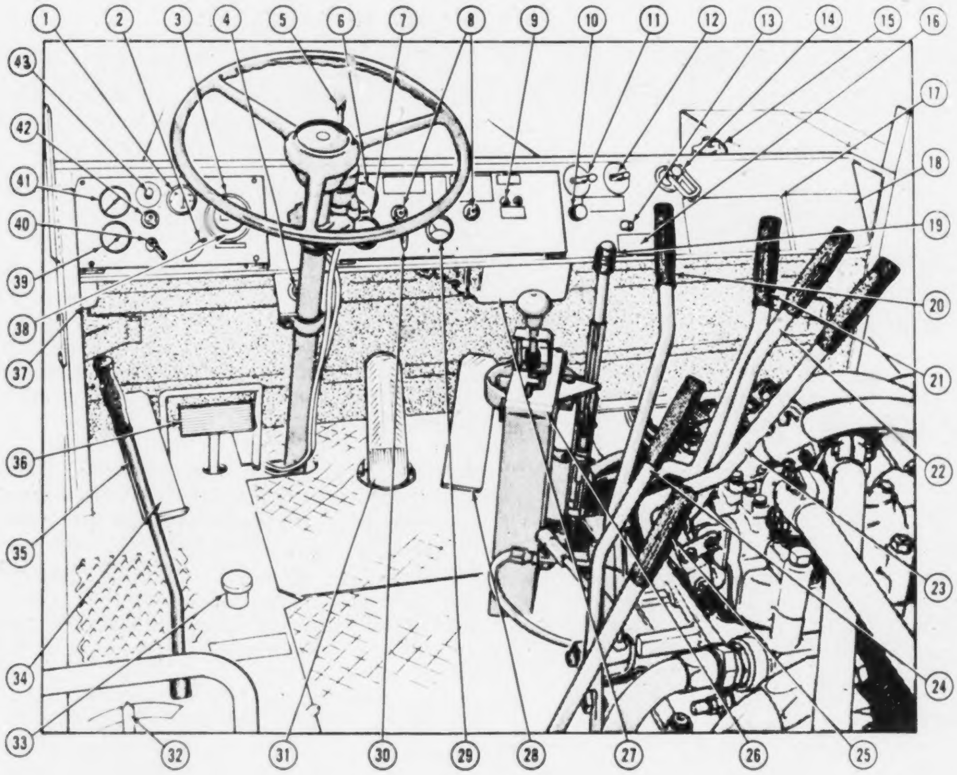
The EMERGENCY STEERING CONTROL (4) is located on the forward side of the steering column. This pushbutton controls the electric motor driven hydraulic pump for the emergency front steering in case of engine failure. The front wheel steering control valve automatically reverts to a manual steering system.

The TRAILER BRAKE CONTROL LEVER (5) is mounted on the front side of the steering column directly under the steering wheel. It is used to operate the brakes of the trailing vehicle independently of the tractor wheel brakes.

The TRANSMISSION OIL TEMPERATURE GAGE (6) is located on the upper center of the instrument panel above the transmission oil pressure gage. It indicates the temperature of the transmission oil.

The TRANSMISSION OIL PRESSURE GAGE (7) is located on the lower center side of the instrument panel below the transmission oil temperature gage. It indicates the transmission main clutch oil pressure.

There are two LIGHT SWITCHES (9) located on the right-hand side of the instrument panel.



1. Ammeter
2. Engine Shutdown Cable
3. Hourmeter
4. Emergency Steering Control
5. Trailer Brake Control Lever
6. Transmission Oil Temperature Gage
7. Transmission Oil Pressure Gage
8. Panel Lights
9. Light Switches
10. Windshield Wiper Control
11. Thermatic Fan Control
12. Tractor Protection Valve
13. Differential Lock Control Lever
14. Cold Weather Starting Aid
15. Air Cleaner Restriction Indicator
16. Differential Lock Data Plate
17. Control Valve Instruction Plate
18. Transportation Data Plate
19. Parking Brake Lever
20. Dozer Tilt-Raise Lever
21. Bowl Lever
22. Apron Lever
23. Ejector Lever
24. Dozer Pitch Lever
25. Winch Control Lever (when installed)
26. Transmission Shift Lever
27. Generator Regulator
28. Accelerator
29. Air Pressure Gage
30. Emergency Stop Cable
31. Footbrake Treadle
32. Rear Steering Position Indicator
33. Brake Reservoir Dipstick
34. Rear Steering Control Pedal
35. Rear Steering Lever
36. Converter Brake (Retarder) Pedal
37. Warning Buzzer
38. Tachometer
39. Engine Coolant Temperature Gage
40. Ignition Switch
41. Engine Oil Pressure Gage
42. Panel Light
43. Starter Button

115.273X

Figure 9-35.— Controls and instruments.

The left-hand switch controls the panel light, taillight, and left-hand headlights. The right hand switch controls the right-hand headlight, rear work light and stop light.

The THERMATIC FAN CONTROL (11) is a toggle action control valve located on the right-hand side of the instrument panel. This valve controls the air pressure to the engine fan allowing the operator to disconnect the fan during fording operations.

The TRACTOR PROTECTION VALVE (12) is a toggle action control valve located on the right-hand side of the instrument panel. This valve controls the air to the trailer brake to prevent the brakes from locking.

The DIFFERENTIAL LOCK CONTROL LEVER (13) is centrally located on the instrument panel. It is integral with the two compressed air control valves and is used to shift the differential locks into and out of engagement.

CAUTION: Do not use the differential locks above second speed range.

The ENGINE PRIMER (14), located on the right side of the tractor dash, is used as a cold weather starting aid (below +40F.) It requires an ether bulb-type cartridge which is inserted into the primer body, punctured and discharged into the engine air intake.

The PARKING BRAKE (19) is used to apply the tractor parking brake. Its knurled handle also is used to adjust tension on the parking brake cable.

The DOZER BLADE TILT CONTROL LEVER (20) is mounted on the control valve forward of the dozer pitch lever. It is used to control the tilt and the raising or lowering of the dozer blade. (See fig. 9-36.)

CAUTION: Before operating the dozer be sure the travel lock bar assemblies are released (fig. 9-37).

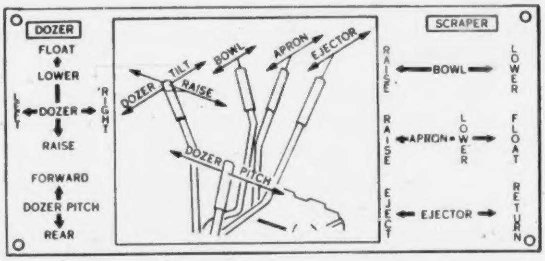


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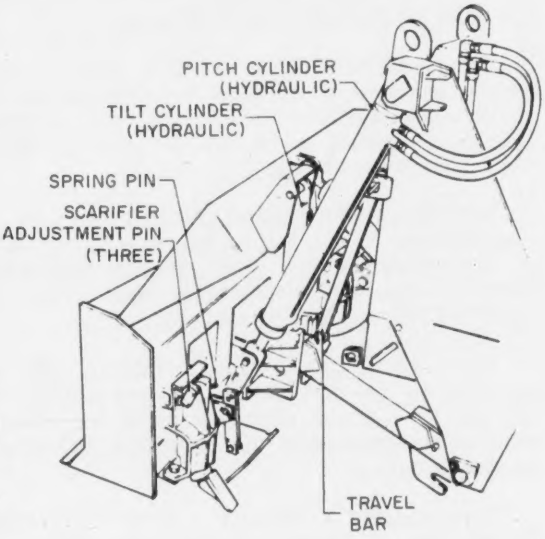
Figure 9-36.—Dozer and scraper operation control levers.

The scraper operation is controlled by three levers: a SCRAPER BOWL CONTROL LEVER (21) which controls the bowl raise and lower functions; a SCRAPER APRON CONTROL LEVER (22) which controls the apron raise and lower functions; and a SCRAPER EJECTOR CONTROL LEVER (23) which controls the raise and lower functions of the ejector. The power control unit is constructed so that each control will return to the neutral position when released. Each lever is moved toward the operator for raise; away from the operator for lower. (See fig. 9-36.)

The DOZER PITCH CONTROL LEVER (24) is mounted on the control valve to the right of the operator's seat. It is used to control the pitch of the dozer blade. (See fig. 9-36.)


PITCH CYLINDER (HYDRAULIC)
TILT CYLINDER (HYDRAULIC)
SPRING PIN
SCARIFIER ADJUSTMENT PIN (THREE)
TRAVEL BAR

115.275X
Figure 9-37.—Dozer blade attachments.

The TRANSMISSION SHIFT LEVER (26) is located to the right of the operator's seat and provides the selection of 6 forward speeds and 2 reverse speeds.

The ACCELERATOR PEDAL (28) is mounted on the front floorboard to the right of the service brake pedal. It is used to control engine speed.

The AIR PRESSURE GAGE (29) is located at the bottom center of the instrument panel. It indicates the air pressure in the airbrake system.

The EMERGENCY STOP CONTROL (30) is located near the lower center of the instrument panel. It is pulled out to stop the engine when normal shutdown procedures fail.

NOTE: After using the emergency stop control, the valve on the blower must be reset manually before restarting the engine.

The SERVICE BRAKE TREADLE (31) is mounted on the front floorboard to the left of the accelerator pedal. It is used to apply brakes to all four wheels of the tractor and to a trailing vehicle when connected.

The REAR STEERING DIRECTIONAL INDICATOR (32) is immediately to the rear of the rear steering lever. It is mechanically linked to the rear wheel steering arm and indicates the steering attitude of the rear wheels.

The REAR STEERING PEDAL (34) is mounted on the left side of the tractor front floorboard. It is mechanically linked to the rear steering hydraulic control valve and is used to steer the tractor rear wheels.

The REAR STEERING LEVER (35) is located immediately to the left of the operator's seat. It is attached to the rear steering hydraulic control valve and is used as a hand control to steer the tractor rear wheels only.

The CONVERTER BRAKE PEDAL (36) is mounted to the left of the steering column. A stirrup is mounted over the pedal to prevent accidental actuation of the converter brake (retarder) pedal.

The ENGINE COOLANT TEMPERATURE GAGE (39) is located in the lower left hand corner of the instrument panel directly under the engine oil pressure gage. It indicates the temperature of the engine coolant.

The IGNITION SWITCH (40) is in the lower left-hand quarter of the instrument panel. Its purpose is to provide an ON and OFF control for electric current to the instruments and to the starter pushbutton switch.

The ENGINE OIL PRESSURE GAGE (41) is in the upper left hand corner of the instrument panel. It indicates engine oil pressure.

The STARTER PUSHBUTTON SWITCH (43) is located near the upper left-hand corner of the instrument panel above the ignition switch. It is used to start the engine.

Starting The Engine

In starting the M.R.S. model I-110 rubber-tired tractor engine under normal conditions, follow the step by step procedure given below.

(1) Be sure the transmission shift lever is in neutral (N) position. If the transmission shift lever is not placed in neutral, the interrupter switch prevents starting the engine.

(2) Place the parking brake lever in the applied position.

(3) Make sure the emergency stop control is all the way in against the dash.

(4) Turn the ignition switch clockwise to the ON position.

(5) Depress the accelerator pedal to the half-way position.

(6) Depress the pushbutton starter switch until the engine starts; then release the pushbutton and ease off on the accelerator pedal.

As soon as the engine starts, observe the gages on the dash for proper readings. Run the engine at part throttle and no load for approximately 5 minutes allowing the engine to warm up. Once again check all instruments prior to operation.

In starting the M.R.S. model I-110 rubber-tired tractor engine under cold weather conditions, or whenever other circumstances make starting difficult, proceed as follows:

(1) Perform steps 1 through 4 as in normal starting.

(2) Unscrew the cap from the ether primer. Insert an ether primer cartridge with its neck forward and screw the cap down on the body of the primer.

(3) Depress the accelerator pedal, approximately three-quarters of the full distance.

(4) Press the starter button. After the starter motor has brought the engine up to cranking speed, discharge the pressure primer bulb by swinging the actuating lever through 180° to the opposite side of the primer. The primer cartridge takes about 15 seconds to discharge fully.

(5) Observe the instruments for proper reading.

> NOTE: Crank the engine for 30 seconds at a time; if it does not start, allow the cranking motor to cool for at least 60 seconds before cranking again.

This engine cannot be cranked by towing. If battery output is insufficient to start the engine, connect an external source of 24 volt direct current to the tractor electrical system by means of the electrical receptacle on the right side of the tractor.

Steps For Operating

Observe the following operating steps for placing the M.R.S. rubber-tired tractor in motion after the engine has been started:

(1) Set the tractor engine at idle speed.

(2) After air pressure is obtained, shift the transmission range lever to the speed range desired (six forward, two reverse).

(3) Release the parking brake.

(4) Depress the accelerator pedal slowly until desired speed is reached.

An automatic front wheel drive selector will engage the front wheel drive when the transmission range lever is in the first and second ranges of forward and reverse. This automatic front wheel drive selector will disengage when the tractor is shifted to third range, forward.

Stopping The Tractor

When bringing the tractor to a stop, proceed as follows:

(1) Release foot pressure from the accelerator pedal.

(2) Apply foot pressure to the service brake pedal.

(3) Shift the transmission range lever to neutral.

(4) Apply the parking brake; this action locks the transmission in neutral.

(5) Lower the dozer blade to the ground.

Stopping The Engine

To stop the tractor engine, here are the steps to follow:

(1) With no load on the engine, decrease engine speed and allow the engine to idle at half speed or less for 4 to 5 minutes (always allow the engine to idle for this period before stopping to permit gradual and uniform cooling).

(2) Pull the engine shutdown cable control to place fuel injectors in the no fuel position.

(3) After engine stops, place ignition switch in the OFF position.

> NOTE: Be sure the ignition switch is turned off before leaving the tractor. The constant drain of the current to the instruments will discharge the battery if the ignition switch is left on.

If the normal shutdown procedures fail to stop the engine, pull the emergency stop control handle out as far as it will go. This will stop the engine by cutting off the combustion air supply from the blower.

After the engine has stopped, push the emergency stop handle all the way in against the dash.

After using the emergency stop control, the valve on the blower must be reset manually before restarting the engine.

> NOTE: Be sure to notify the field mechanics if the engine's normal shutdown equipment is no longer operational.

Operation Capabilities

Operating techniques which were described in previous sections as to the operation of the crawler-type tractor also apply basically to the rubber-tired tractor. As pointed out below, there are some differences, however, in the application of the dozer blade and attachments when it comes to dozing techniques.

With the model I-110 tractor, the dozer blade control lever (number (20) fig. 9-35) is used not only for raising and lowering the blade, but also for tilting the blade. An additional control lever, known as the dozer blade pitch control lever (number (24) fig. 9-35), is used to pitch the dozer blade forward or rearward, depending upon the condition of the ground. Generally, the blade is pitched back for soft ground and forward for hard ground.

Other attachments on the dozer blade (fig. 9-37) include three scarifiers for backripping operations. In addition, travel lock assemblies are mounted on the front of the radiator guard to hold the blade in the travel position. Before moving the tractor, be sure to raise the dozer blade to its extreme travel; also, remove the two pins and use them to attach the lock assemblies to the travel lock bracket provided on the push frame.

CAUTION: Always release the travel locks before operating the dozer controls.

The M.R.S. model I-110 rubber-tired tractor is designed to stop, start, and negotiate a 30-percent longitudinal slope. For slope operation, the tractor is capable of loading a scraper on a 20-percent side slope.

If the grade is short, the tractor may be worked from the bottom directly up the slope; if the grade is comparatively long, it must be worked from above. Care must be taken that the tractor is steered directly down the slope— not diagonally. A diagonal course down a steep slope may cause the tractor to overturn.

For sidehill cuts, be sure to adjust the bank side of the dozer blade lower than the outer side. This will greatly aid in holding the tractor against the bank and securing a satisfactory and controllable cut. Work down from above the cut to start a shelf. Work from this self along the slope line, digging with one corner of the blade and swinging away from the hill side. Keep the downhill side of the cut high. Build a shelf along in front of the tractor as it travels forward.

Keep in mind that the M.R.S. model I-110 tractor is not designed primarily as a bulldozer; but as a prime mover for a rubber-tired scraper.

HAND SIGNALS

A uniform system of hand signals must be used on all tractor operations of a similar nature. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be located so as to be clearly visible to the operator at all times. The hand signals used in tractor and attachment operations are depicted in appendix I. It is important that you not only recognize and understand these hand signals when operating equipment, but also be able to give them when called upon to act as a signalman on a construction project.

SECURING

When securing a crawler tractor, position the attachment for traveling, drive the tractor to the designated securing area, and position the machine in a safe manner. After the machine has stopped, lower the attachment to the ground, set the brake lock, and place the transmission in neutral position. Then allow the engine to throttle down to slow idle (no load) for 3 to 5 minutes before moving the engine speed control lever to shut-off position and stopping the engine. After the engine stops, place the electrical system master switch in the "OFF" position.

When securing a rubber-tired tractor, position the attachment for traveling, drive the tractor to the designated securing area, and position the machine in a safe manner. After parking the machine, lower the attachment to the ground, set the parking brake hand lever, and place the transmission shift lever in neutral position. Then allow the engine to throttle down to slow idle (no load) for 4 to 5 minutes before pulling the engine shutdown cable control and stopping the engine. After the engine stops, place the ignition switch in the "OFF" position. Drain the air tanks by opening the drain cocks.

OPERATOR'S MAINTENANCE

The procedures used in an operator's maintenance inspection of the various components of tractors are the same as described in previous portions of this manual for vehicles and materials-handling equipment, and need not be repeated here. These components include brake systems, fuel systems, ignition and electrical systems, cooling systems, and lubricating oil systems. Items such as fan belts, batteries, transmissions, and wheels and tires were also discussed.

In addition to the above, the tractor has two other components, the hydraulic system and the air cleaner system, which will be covered below.

HYDRAULIC SYSTEM

When inspecting the hydraulic system, ensure that the proper level of hydraulic oil is maintained in the hydraulic reservior. Be sure to add the type of hydraulic oil recommended by the manufacturer. This is especially important because some hydraulic systems are equipped with natural rubber packing seals and others with synthetic rubber packing seals. And unless the recommended hydraulic oil is used, the packing seals will deteriorate quickly and cause the system to leak. Check the hydraulic lines for leaks, and if any are found, tighten hose connections. In addition, check the hydraulic cylinders to ensure that they hold the load. If they fail to hold the load, tighten the cylinder packing nuts.

AIR CLEANER SYSTEM

Most tractors are usually equipped with some type of an air cleaner service indicator. This device will normally actuate as dirt accumulates in the filter element and reaches the maximum allowable restriction. When this happens, the filter element must be removed and cleaned, either by washing or with compressed air. Washing is the preferred method as it removes more dust and soot and restores the element to an almost new condition. It is suggested that a spare element be available for use while the serviced element is drying. This will reduce downtime to only a few minutes and will allow sufficient time to service the restricted element properly.

Cleaning the element with compressed air is not considered an entirely satisfactory method. Some dust will remain in the element causing more frequent servicing. Use this method only as a temporary measure until sufficient time is available to clean the element by washing.

CAUTION: Never wash elements in fuel oil, gas or solvent. DO NOT OIL ELEMENTS. Do not attempt to take elements apart. Do not tap the element against a hard surface; this will damage the element.

LUBRICATION

The life and performance of a tractor depends on the care that it is given. Proper lubrication, performed at definite intervals, will aid greatly in prolonging the life of the tractor and in reducing operating expense. The type of work being done, loads handled, ground and weather conditions, are all factors to consider in determining the frequency of lubrication. It may be necessary to lubricate more frequently when working under severe operating conditions such as heavy dust, low engine temperature, intermittent operation, excessively heavy loads with high oil temperatures, or when diesel fuel with a high sulphur content is used. However, the time intervals between lubrication periods must never exceed those indicated on the lubrication chart.

A lubrication guide for the International Harvester model of crawler tractor is presented in figure 9-38. The guide shows a lubrication chart indicating the points on the crawler tractor to be lubricated and the lubrication intervals. A specification and capacity chart showing the type and amount of lubricant to use is presented in figure 9-39.

A lubricating guide for the M.R.S. model rubber-tired tractor is presented in figure 9-40. This guide indicates how often to lubricate, what to lubricate, and what lubricant to use. The lubricating chart shown in figure 9-41 indicates the points on the rubber-tired tractor to be lubricated and provides a key to the symbol, type, application, and specification of lubricant to use.

ADJUSTMENTS

Adjustment procedures for fan belts and hand-operated parking brakes used on tractors, which would normally be made by the EO, are basically the same as those given in chapter 5 of this manual for automotive vehicles; therefore, the procedures need not be repeated here.

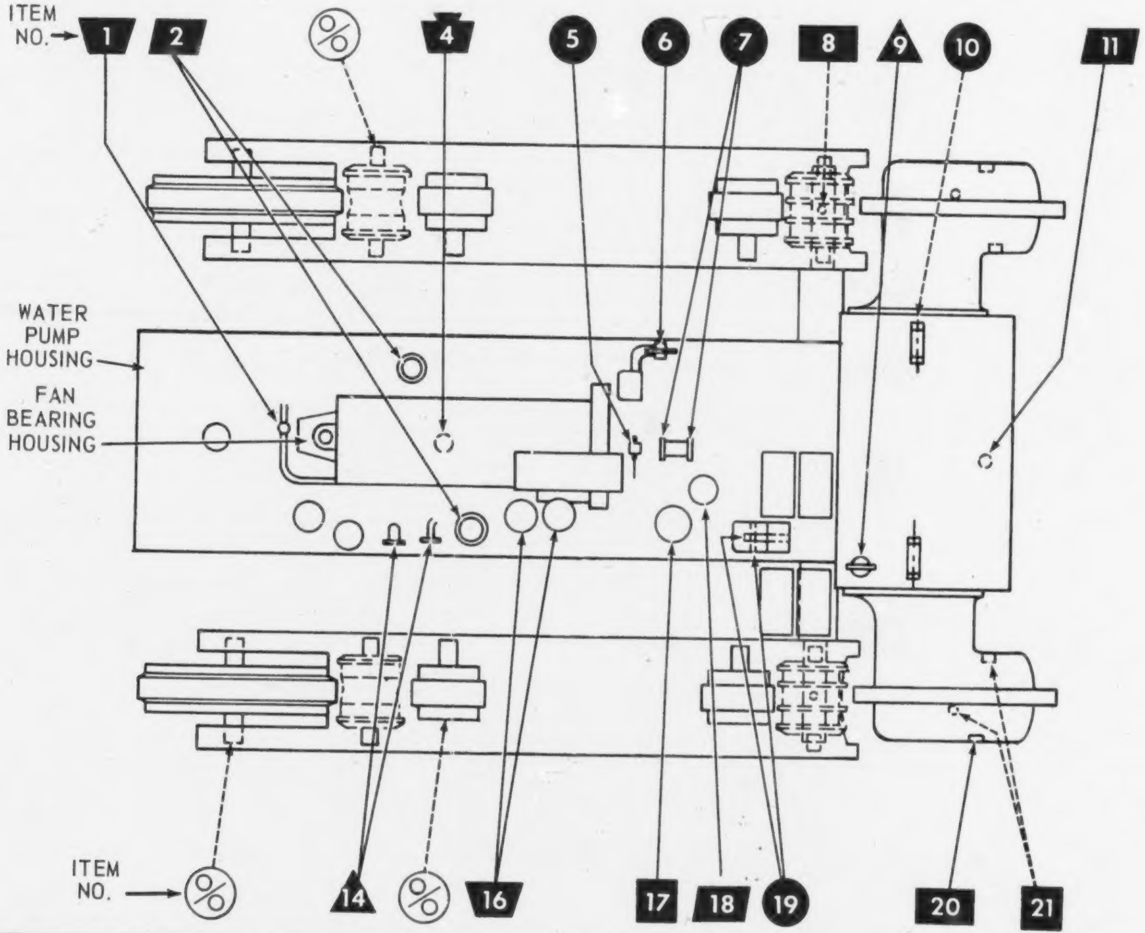
In this discussion, information as to the procedures for checking and adjusting track tension on the International Harvester model TD-20B series crawler tractor will be covered.

Checking Track Tension

Improper track tension will cause damage and premature wear to the track. In checking for track tension, here is the procedure to follow:

1. Place a wooden block, approximately 1 foot in height, under the foremost track shoe lug.
2. Start the engine and move the tractor forward just enough so that the sprocket drive tightens the track chain along the ground and around the sprocket.
3. Apply and lock the brake; stop the engine.
4. Place and lock the transmission gear selector lever in the "NEUTRAL" position.
5. Stand on the track between the track idlers; this will pull the track chain tight around the idlers and accumulate all the slack at this point.

NOTE: ALL DOTTED SHAFT ARROWS INDICATE POINTS THAT MUST BE LUBRICATED ON BOTH SIDES OF TRACTOR.



% FRONT IDLERS, TRACK IDLERS AND TRACK ROLLERS ARE LUBRICATED FOR LIFE WITH A GRADE-30 ENGINE OIL WHEN ASSEMBLED AND DO NOT REQUIRE ADDITIONAL LUBRICATION EXCEPT WHEN RECONDITIONED, THEN INSTALL (SERIES 3 OR MIL-L-45199A) GRADE-30 ENGINE OIL.

115.452.1

Figure 9-38.—Lubrication chart for crawler tractor (TD-20B series).

LUBRICATION INTERVAL		ITEM NO.	POINT OF LUBRICATION	LUBRICANT	REMARKS
Every 10 hours	▲	9	Rear frame oil level	EO	Check
		14	**Crankcase oil level**	EO	Check
Every 50 hours	●	5	Governor control upper and lower bell crank	MPG	Grease
		6	Brake pedal	MPG	Grease
		7	Universal joint	HTG	Grease
		10	Steering brake shaft	MPG	Grease
		19	Upper and lower shifter bell crank shafts	MPG	Grease
Every 100 hours	⬟	4	Crankcase oil	EO	Change
Every 200 hours	⏢	1	Front engine support	MPG	Grease
		16	Lubricating oil filter elements	- - -	Change
Every 250 hours	▬	8	**Track frame pivot shaft housings**	MPG	Grease
		20	**Sprocket drive housing oil level**		
Every 500 hours	■	17	Transmission, torque converter and steering booster pressure filter element	- - -	Change
		21	**Sprocket drive housing oil**	MPL	Change
Every 1000 hours	▰	2	Transmission, torque converter and steering booster safety filter element	- - -	Clean
		11	Rear frame oil	EO	Change
		18	Transmission, torque converter and steering booster suction filter element	- - -	Clean

115.452.2

Figure 9-38.—Lubrication chart for crawler tractor (TD-20B series)—Continued.

6. Place a straightedge on the track and check the slack as shown in figure 9-42. If the clearance is less than 3/4 inch or more than 1 inch, adjust the track tension.

Adjusting Track Chain Tension

Before attempting to adjust track chain tension, you should first become familiar with the location and functions of the hydraulic track adjuster. Figure 9-43 shows the hydraulic track adjuster of the International Harvester model TD-20B series crawler tractor.

Track chain tension is adjusted by hydraulic pressure. The front idler is forced forward for track adjustment by chassis lubricant under pressure with the standard type bucket or hand lubricator. The pressure in this system is held by the socket head screw and a check valve under the lubricating fitting. NEVER loosen the socket head screw more than ONE turn, and NEVER remove the socket head screw under pressure.

Ensure that you remove the scraper, then connect the lubricator nozzle to the fitting under

LUBRICANT KEY: EO - Engine Oil
MPL - Multi-purpose Type Gear Lubricant
MPG - Multi-purpose Grease
HTG - High Temperature Grease

LUBRICATION POINT	CAPACITY	ANTICIPATED AIR TEMPERATURES Above +32°F	 +32°F to -10°F	 Below -10°F
Crankcase: With filters drained With filters changed	 25 qts. 27 qts.	EO - SERIES 3 or MIL-L-45199A. Grade-30	 Grade-10	24 qts. Grade-10 Diluted w/ 3 qts. Kerosine
Rear Frame ⑥	40 gals.	EO - SERIES 3 or MIL-L-45199A. Grade-10		MIL-L-10295A or DEXRON ATF
Hydraulic System (tractor equipment): Model D-1 or D-3 (equipped with hydraulic tilt) Model D-2 or G-2 (equipped with hydraulic tilt) Model D-2 or G-2 (not equipped with hydraulic tilt)	 3 gals. 28 gals. 26 gals.	EO - MIL-L-2104B, Sup. 1, DEF. 2101C, SERIES 3 or MIL-L-45199A. Grade-10		
Track Roller (each) ⑧ Track Idler (each) ⑧ Front Idler (each) ⑧	2-1/4 pts: 3 pts. 2 pts.	EO - SERIES 3 or MIL-L-45199A. Grade-30		
Sprocket Drive Housing (each)	28 qts.	MPL - IH B-22 Grades 132H EP, 134H EP or MIL-L-2105B Grade-90 ⑦	 Grade-80 ⑦	MIL-L-10324A
Water Pump Housing Fan Bearing Housing Pivot Shaft Housing (each)	1/2 oz. 2-1/2 oz. 2 qts.	MPG - I.H. 251H EP or equivalent		
Cable Control Unit: MODEL 110 (gear case) MODEL 260 (main housing) MODEL 260 (transfer case) MODEL 260S (main housing)	 4-1/2 qts. 9 qts. 1 qt. 8 qts.	EO - SERIES 3 or MIL-L-45199A Grade-50	 Grade-30	
All lubrication fittings	Fill as instructed	HTG - MIL-L-3545 or MIL-G-3545A as indicated on the "LUBRICATION GUIDES"		

⑥ - Common reservoir for planetary steering, hydraulic steering boosters, torque converter and transmission.

⑦ - A multi-grade 80-90 may be used at temperatures between -20°F and +90°F. A Grade-140 may be used at temperatures above +90°F.

⑧ - Front idlers, track idlers and track rollers are lubricated for life.

115.453

Figure 9-39.—Specification and capacity chart for crawler tractor (TD-20B series).

the opening and add lubricant to obtain the proper track chain tension. It is advisable to move the tractor forward and backward slightly to be sure the correct tension has been obtained.

To reduce track chain tension, loosen the socket head screw one full turn. This will allow the check valve ball to unseat and furnish a relief passage for the pressurized lubricant. When the proper tension has been obtained, tighten the socket head screw.

When the tractor chain tension adjustments have been completed, install and fasten the scraper.

CAUTION: When working tracked equipment in materials such as sand or snow, the tracks tend to further tighten.

TRACTOR TIRES

Inspecting, checking, and maintaining tractor tires is a primary responsibility of the EO. Inspection of tires consists of checking for missing valve caps, leaking valves, cuts, breaks, abrasions, and imbedded foreign matter. Some punctures can be repaired without removing the tire. When major damage or a blowout occurs, or normal wear limits have been reached, the tire must be removed. Size alone makes the removal and replacement of tractor tires difficult. In addition, the nature of the terrain over which tractors operate, and locations of many operations, often cause conditions to be far from ideal. Certain tools are necessary to change these large tires. Hand tire tools and hydraulic tire tools are specifically designed to break the beads, for easier removal of the tire.

Figures 9-44 through 9-47 indicate procedures for demounting and mounting tractor tires (on machine), and mounting, as well as demounting tires (off machine).

For your safety—remember, an inflated tire and the rim on which it is mounted can be very dangerous; under pressure it packs the explosive force of TNT.

In demounting a tractor tire, be sure to remove the valve core and exhaust ALL air from the tire. Next check the valve stem by running a wire through the stem to be sure it is not plugged. A broken rim part under pressure could blow apart and kill you the moment you remove the lugs on the assembly. Remove valve cores from BOTH tire assemblies if so equipped.

Use a clip-on chuck and extension hose long enough to allow you to stand to one side and NOT in front of the tire assembly while inflating.

Be careful to clean all dirt and rust from the lockring gutter. This is important to allow the lockring to secure in the proper position. Inspect the rim base and lockring gutter for cracks. Any cracked, damaged, or sprung rim bases or lockrings should be replaced.

Bead breakers and rams apply pressure to bead flanges. KEEP YOUR FINGERS CLEAR. Slant a bead breaker about 10 degrees to keep it firmly in place. If it slips off, it can fly with enough force to kill. ALWAYS stand to one side when you apply hydraulic pressure.

When using a cable or chain sling, stand clear. It might snap and lash out.

Never attempt to rework, weld, heat, or braze wheel parts. Always replace with new parts of the same size, type, and make.

Spare tires mounted on demountable rims should only have enough air pressure to keep the rim parts in place. NEVER TRANSPORT A FULLY INFLATED TIRE. Inflate tires to correct operating pressure AFTER the tire and rim assembly have been fastened in place with all lug nuts properly torqued.

Be sure you note the following:

THE TRACTION DIRECTION ARROW ON THE TIRE TREAD IS TO POINT IN THE OPPOSITE DIRECTION AS THE ROTATION OF THE WHEEL.

It is recommended that clamp-on inflation hoses, safety chains, or some other safety device be used during inflation.

Inflation air lines should have traps to prevent airborne moisture or oil from getting into the tire and causing rim corrosion or tire deterioration.

CHANGING FRONT END TRACTOR ATTACHMENT

When it becomes necessary to remove the complete hydraulic or cable operated blade from the tractor, proceed as follows:

1. Place the blade on level ground and block up the ends of the C-frame or push arms which are closest to the trunnions. This will maintain a proper height for reassembly.

DESCRIPTION (NO. POINTS)	LUB.	HRS.	DESCRIPTION (NO. POINTS)	LUB.	HRS.
1. Pitch Cylinder (2 Pts.)	GAA	10	16. Steer. Cyl Pins (8 Pts.)	GAA	10
2. Check Coolant Level		Daily	17. Steering Knuckles (4 Pts.)	GAA	50
3. Fuel Filter		Daily	18. Tie Rod Ends (4 Pts)	GAA	10
4. Engine Oil Filter		Monthly	19. Drive Shafts (6 Pts.)	GAA	50
5. Air Cleaner		Daily	20. Check Strainer in Filler Neck		Weekly
6. Trans. Check (Dipstick)	OE	10	21. Rear Steer Ind. (1 Pt.)	GAA	25
7. Hyd. Oil Check (Dipstick)	OE	10	22. Brake Oil Check (Dipstick)	OE	10
8. Hydraulic Oil Filters		500	23. Trans. Shift Indicator (1 Pt.)	GAA	10
9. Hyd. Control Links (6 Pts.)	GAA	8	24. Rear Steer Pedal (2 Pts.)	GAA	10
10. Transmission Oil Filter		Monthly	25. Final Drive (4 Pts.)	GO	50
11. Batteries		Weekly	26. Engine Oil Check (Dipstick)	OE	10
12. Air Tanks		Daily	27. Front Axle Pivot Pin (1 Pt.)	GAA	10
13. Scraper Coup Ball (1 Pt.)	GAA	10	28. Lift Cylinder (4 Pts.)	GAA	10
14. Differ. Check Plug (2 Pts.)	GO	50	29. Tilt Cylinder (2 Pts.)	GAA	10
15. Pintle Hook (Jaws & Shaft)	GAA	10	30. Sliding Shoes (2 Pts.)	GAA	10
			31. Push Frame (4 Pts.)	GAA	10

115.454

Figure 9-40.—Lubrication schedule for rubber-tired tractor (M.R.S. I-110).

2. For a tractor equipped with a hydraulically operated blade, disconnect the hydraulic cylinder piston rods from the hydraulic jack brackets on the back of the blade. Retract the piston rods into the cylinders and secure the rods in this position.

3. For a tractor equipped with a cable operated blade, remove the capscrews and locknuts holding the lower sheave block universal mounting shaft; then remove the shaft, universal and sheave block from the blade or C-frame. Raise the lower sheave block, with universal, as far as possible and secure it in this position.

4. Remove the two capscrews, nuts and shims from the left and right trunnion bearing caps located at the rear of the C-frame or push arms.

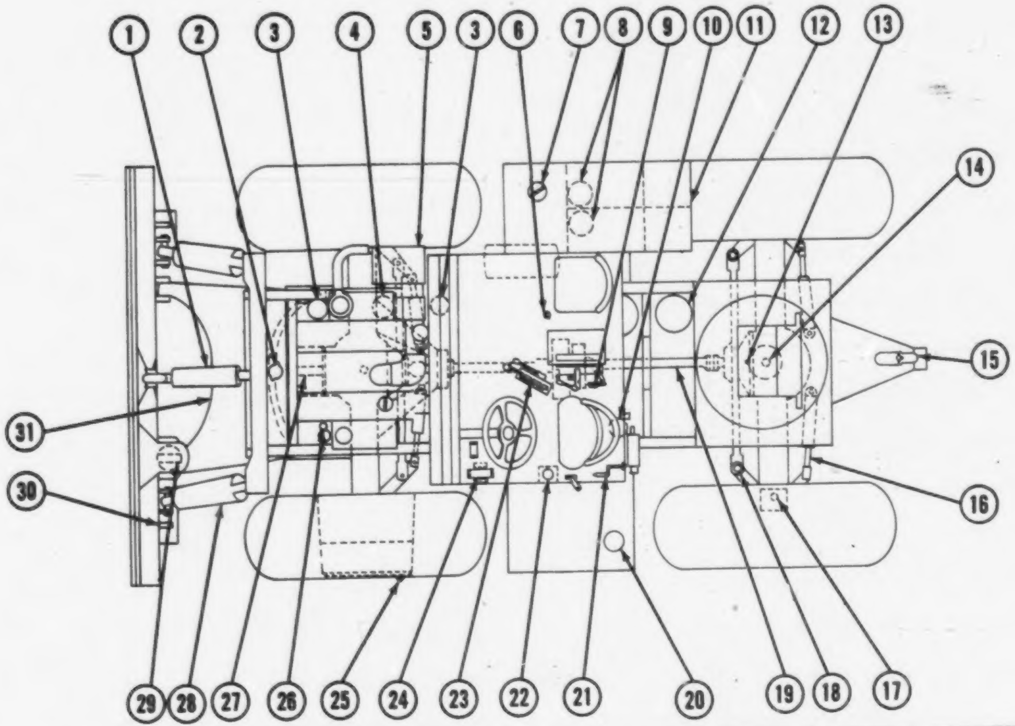
5. Back the tractor out and away from the C-frame or push arms.

6. Reassemble the trunnion bearing cap and shims to the C-frame or push arms to avoid loss or damage. If stored outdoors, coat the trunnion bearing cap and shims with grease to prevent corrosion.

CHANGING REAR MOUNTED TRACTOR ATTACHMENT

When it becomes necessary to disconnect a hydraulically operated scraper from the tractor, proceed as follows:

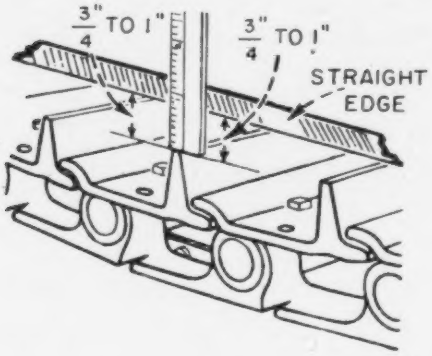
1. With the hydraulic system in operation, put the scraper in a transport position and insert travel lock pins.



SYMBOL	LUBRICANT AND APPLICATION	TEMPERATURES	
		ABOVE +32°F	+32°F TO -25°
OE	OIL, Engine Engine Crankcase	SAE 30 MIL-L-2104	SAE 10 MIL-L-10295
	Transmission, Hyd.Tank, Brake Reservoir	SAE 10 MIL-L-2104	
GO	OIL, Gear Final Drive, Differential	SAE 90 MS GO-90 MIL-L-2105	
GAA	Grease, Automotive & Artillery All Pressure Gun Fittings	MIL-L-10924	

115.455

Figure 9-41.—Lubricating chart for rubber-tired tractor (M.R.S. I-110).



115.456
Figure 9-42.—Checking slack in track chain of a TD 20B series tractor.

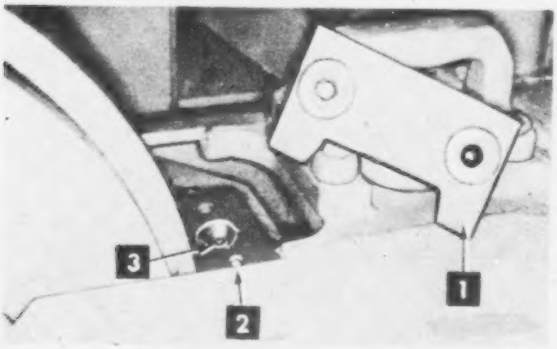
2. Put ejector all the way down and close apron.

3. Screw jack for positioning headframe and scraper tongue. This will maintain proper height for reassembly.

4. Stop tractor engine.

5. Work all hydraulic levers in both directions to relieve hydraulic pressures.

6. Disconnect the hydraulic hoses from their respective openings in the manifold on the head frame of the tractor.



1. SCRAPER, FRONT IDLER.
2. SCREW, SOCKET HEAD.
3. FITTING, LUBRICATION.

115.457
Figure 9-43.—Hydraulic track adjuster of a TD 20B series tractor.

7. Pull the tractor drawbar pin from the scraper tongue.

8. Start the tractor engine and move the tractor away from the scraper unit.

SAFETY

Standard safety precautions applying to tractors follow:

1. Equipment must be operated at no greater speed than the maximum at which the machine can be kept under control at all times.

2. Navy safety regulations require that all dozers used in clearing operations be equipped with crankcase guards and radiator protectors. All dozers purchased by the Navy are equipped with these features, and they must never be used in clearing operations without the features in place.

3. When using a dozer for demolition, care must be taken to prevent falling objects from striking the operator or other personnel.

4. When felling trees with a dozer, the greatest care must be taken to avoid being struck by falling branches, or by the backlash of a branch or trunk. Whenever possible, it is highly advisable to erect an overhead guard, consisting of a framework of pipe or some similar structure, to protect the operator.

5. Men must NEVER ride the drawbars of tractors. This dangerous practice has been the cause of numerous accidents.

6. Operators of dozers and rippers should make every effort to learn the locations of any underground high voltage electric lines or gas lines which might be contacted by their equipment.

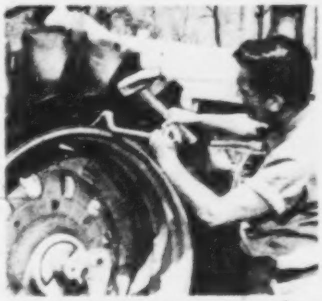
7. A tractor must not be operated near the edge of a cut; the edge may give way, overturning the machine. An overturning machine is very likely to crush its operator.

8. A steep incline should be climbed slowly. "Gunning" up a steep slope has often caused overturning.

9. Do not attempt a turn on a steep slope. Sliding sideways may not appear to be dangerous, but it can easily become so if the low side of the rig hits a solid rock or a stump.

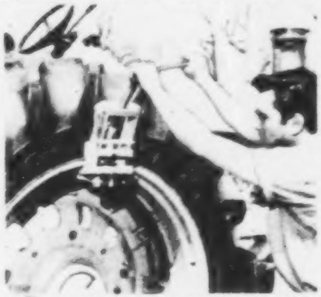
10. Before starting a tow, carefully check the towing hitch. A runaway tow is a very dangerous hazard.

11. Chains, wire rope, and other makeshifts must not be used for towing. Always use a towbar.

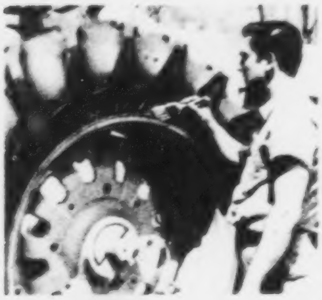


1 With vehicle jacked up on the side which is to have the tire removed, and after fluid has been removed, remove rim nut and core housing to completely deflate. Push valve through valve hole.

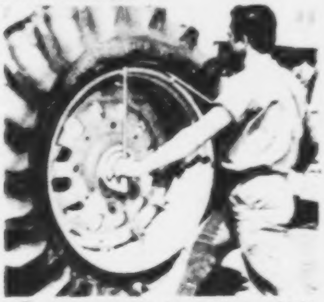
Using a "bead breaking" tool and a heavy hammer, drive the tool between the tire bead and the rim flange, being careful not to damage bead area. Beads should be unseated on both sides of rim.



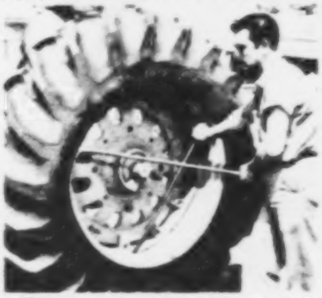
2 As an alternative to the procedure above, a bead unseating tool and instructions are available from Iowa Mold Tooling Company.



3 Thoroughly lubricate rim flange, tire bead and base of tube with a thin solution of vegetable oil soap in water or equivalent rubber lubricant recommended for this requirement. (Never use petroleum-base solution or silicones.)

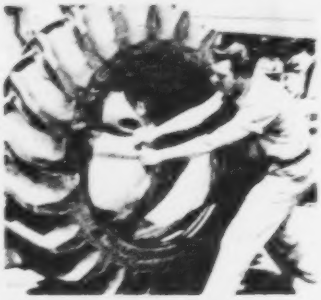


4 Lock wheels by putting vehicle into gear with valve at top. Force outside bead at bottom into rim well. Insert long tire irons under bead at the top and pry bead over rim flange. Take short bites to avoid extremely hard prying and possible damage to tire bead.

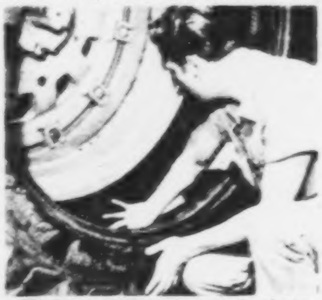


5 **After first section of bead is over rim flange, use one iron to hold that section over flange and use other tire iron to pry next section over flange. Do not attempt to pry too large a section over the rim flange at one time.**

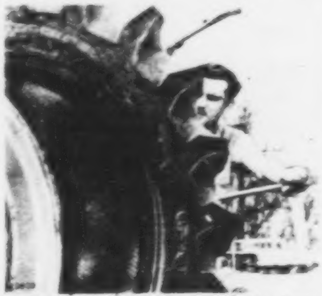
Safety Precaution — *Never release grip on either iron as they may tend to spring back.*



6 Pull tube out of casing. When only tube requires repair or replacement, this can be done without removing tire completely from rim.



7 Thoroughly inspect inside of casing for foreign material or damage and remove moisture from inside of tire.



8 To remove tire completely from wheel, insert tire irons under the inside bead at side of tire. Pry rest of inside bead over rim flange. When starting this operation, be sure that the bead area on opposite side of tire is down in rim well.

115.458X

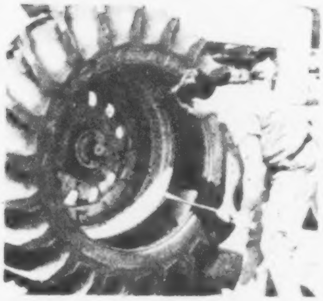
Figure 9-44.—Demounting tractor tires (on machine).

Before mounting a tire on a used rim, be sure the flange area and partciularly, the bead seat area is clean and smooth. Remove any buildup of rust, corrosion or old rubber with chisel or wire brush. Bent, cracked or otherwise damaged rims should be repaired or replaced.

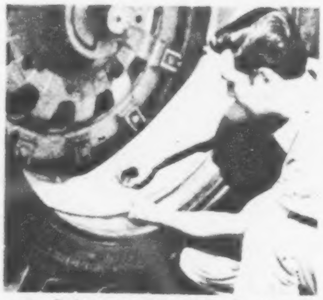
Thoroughly inspect inside of casing for foreign material or damage.

Lubricate both beads with a thin solution of vegetable oil soap in water or equivalent rubber lubricant recommended for this requirement. (Never use petroleum base solutions or silicones.)

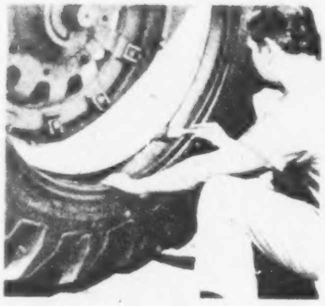
Note. Some steps of the following procedure may require two men on larger size tires.



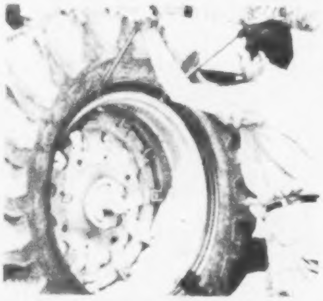
1 To put tire on wheel, place inner tire bead over flange at top. Be sure bead is not on bead seat but is guided into well as tire irons are used to work down either side, forcing rest of inner bead over flange. With first bead on rim, pull tire toward outside of rim as far as possible to make room for tube. Be sure inside of tire is completely dry.



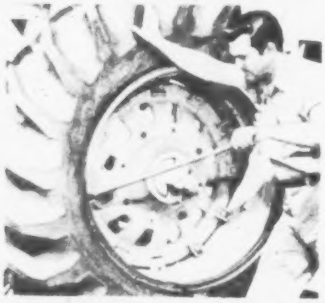
2 Before inserting tube in tire, be sure that valve hole is at bottom of wheel. Align stem with valve hole and place tube in tire starting at the bottom. Place valve in valve hole and screw rim nut on stem to hold it in place. Be sure that tube is well inside rim before proceeding to next step.



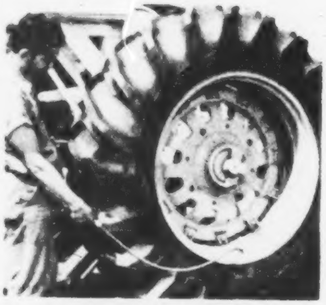
3 Tube should be partially inflated and base area that contacts rim should be lubricated to prevent localized stretching.



4 Starting at top, use tire irons to lift outer bead up and over rim flange and down into rim well. Be careful not to pinch tube in the operation.

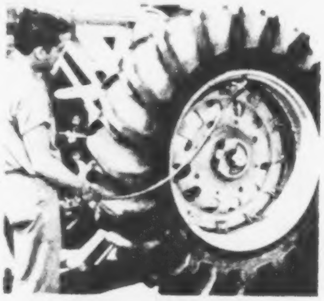


5 After getting first section of outer bead into rim well, place one hand against that section to hold it, and then pry remainder of bead over flange with tire iron in other hand. Do not attempt to pry large sections of bead over flange at one time.



6 Safety Precaution: *Centering the tire is extremely important to prevent broken beads. Remote control inflation equipment should be used. Never stand in front of assembly.*

With valve stem at bottom, lower the jack until tire is centered on rim. Inflate sufficiently to seat beads on rim at bottom.



7 Raise tractor, rotate tire to have valve at top. Inflate to 35 pounds pressure to fully seat beads.

Then remove valve core housing and completely deflate. Reinsert valve core housing and reinflate tire to recommended pressure. **Note.** If either bead should fail to seat at 35 pounds inflation, the tube may be pinched between tire bead and rim, or something else is interfering with proper mounting. *Do not increase inflation pressure to seat beads*, but remove valve core housing and completely deflate tube. Unseat both beads from the rim, relubricate both tire beads and rim bead seat areas, reinstall valve core housing, and reinflate tube to 35 psi. Repeat process until both beads are properly seated.

Reduce to operating pressure before putting tire in service.

Figure 9-45. — Mounting tractor tires (on machine).

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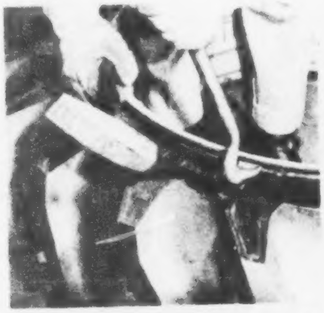
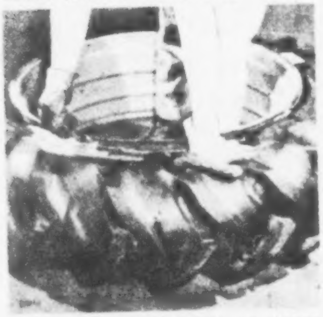
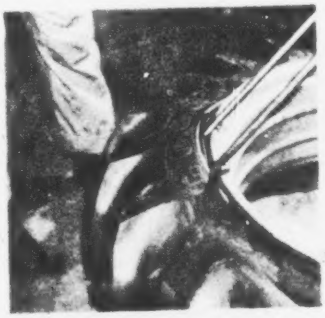


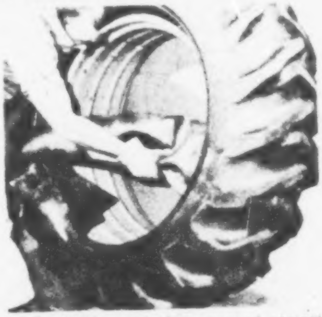
1 To dismount tire, completely deflate tube by removing core housing and remove rim nut. Using a "bead-breaking" tool and a heavy hammer, drive the tool between tire bead and rim flange, being careful not to damage bead area. After bead has been released completely around tire, turn tire and rim over and repeat above procedure with the second bead.



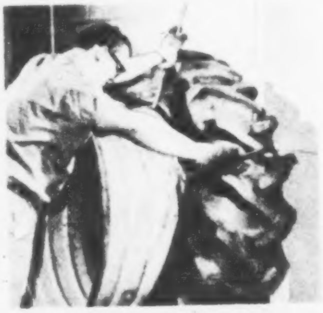
2 Thoroughly lubricate rim flange, tire bead and base of tube with a thin solution of vegetable oil soap in water or equivalent rubber lubricant recommended for this requirement. (Never use petroleum-base solution or silicones.)



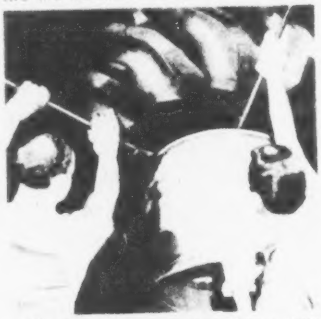
3 With part of top bead forced into rim well, pry opposite side of bead over rim flange using two long tire irons. Continue until top bead is completely over the rim flange.



4 With weight of tire braced against a solid support, pull tube out of tire casing. When only tube requires repair or replacement, thoroughly inspect inside of tire casing for foreign material or damage and make sure inside of casing is dry before reinserting tube.



5 To completely remove tire from rim with weight of assembly supported, be sure one side of bottom bead is in rim well and insert tire irons under opposite side of bead. With smaller size tires work bottom bead over rim flange by taking small bites with two tire irons.



6 Stand large section heavy tires on tread. With weight of assembly supported, and one man holding rim, the second man can work second bead over rim flange until rim drops out.

115.460X

Figure 9-46.—Demounting tractor tires (off machine).

1 Before mounting a new tire on a used rim be sure the flange area and particularly, the bead seat area is clean and smooth. Remove any buildup of rust corrosion, or old rubber with chisel or wire brush. Bent, cracked or otherwise damaged rims should be repaired or replaced. Rim should be laid on the floor with the valve hole on the top side. In the case of a deep well rim, the deep well must always be on top.

Inflate tube until it is rounded out and insert it in the tire with the valve on the top side before starting to mount tire on rim. Lubricate bottom tire bead and top rim flange with a thin solution of vegetable oil soap in water or equivalent rubber lubricant recommended for this requirement (never use petroleum-base solutions or silicones).

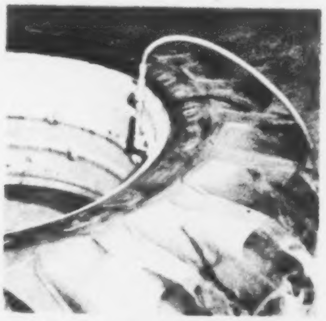
Push bottom bead over rim flange as far as possible. With the tire cocked on rim, screw rim nut finger-tight on valve stem to hold it in place.

2 Using long tire irons, work first tire bead completely over rim flange.

3 Starting opposite the valve, use tire irons to lift top bead over the rim flange and down into rim well. Care must be used to avoid pinching tube with tire irons. When bead is well statred, lubricate remaining unmounted portion of tire bead and rim flange.

4 Tire bead must be forced into rim well when working tire bead over rim flange (lifting opposite side of bead may be required to do this). For small tire, stand on half of tire which is in rim well and work equally around both sides to spoon tire bead over rim flange until final section drops over at the tube valve. Do not attempt to pry large sections of bead over flange at one time.

5 With large section tires a second man may be required to hold tire bead in rim well — either with tire iron or by standing on the tire sidewall.



6 Safety Precaution: *Centering the tire is extremely important to prevent broken beads. Remote control inflation equipment should be used. Never stand over the assembly when inflating.*

Center the tire on the rim and inflate to 35 pounds pressure. Then remove valve core housing and completely deflate. Re-insert valve core housing and reinflate tire to recommended pressure. Note: If either bead should fail to seat at 35 pounds inflation, the tube may be pinched between tire bead and rim, or something else is interfering with proper mounting. *Do not increase inflation pressure to seat beads,* but remove valve core housing and completely deflate tube. Break both beads loose from the rim; relubricate both tire beads and rim bead seat areas; reinstall valve core housing, and reinflate tube to 35 psi. Repeat until both beads are properly seated.

Reduce to operating pressure before putting tire in service.

115.461X

Figure 9-47.—Mounting tractor tires (off machine).

12. Coupling trailing equipment to the tractor is hazardous; be especially alert while this is being done. Whenever possible, it should be done with the tractor stopped and the clutch, if so equipped, disengaged.

13. When towing a heavy load downgrade, keep the tractor in low gear. Coasting is dangerous. A coasting tractor with a tow is very likely to jackknife.

14. At the end of a day's work, secure a dozer blade by lowering it to the ground. Do this also whenever dismounting from the tractor. Lowering the blade takes the weight of the blade off the power unit; more important still, it eliminates the possibility of the blade falling on someone. Whenever it is necessary to work on the dozer with the blade up, the blade must be securely blocked up to prevent accidental falling.

CHAPTER 10

FRONT-END LOADERS

The front-end loader is a self-contained unit mounted on rubber tires or tracks. It is a versatile and capable piece of equipment which can be utilized to dig at ground level, aboveground level, and belowground level.

The power units used with crawler-mounted front-end loaders are nothing more than basic tractors and those used with rubber-tired front-end loaders are similar to forklifts. Because of this, the starting, operation, and maintenance principles are the same as discussed in previous chapters.

Information is presented on the capabilities, gross limits, and utilization of front-end loaders as well as safety precautions to be observed when operating or working near front-end loaders.

TYPES OF FRONT-END LOADERS

Front-end loaders used by the Navy are especially designed to ensure the performance of necessary tactical excavating and hauling functions under varied conditions. Design specifications and performance characteristics of front-end loaders indicate their capabilities and limitations under adverse conditions. You must recognize these capabilities and limitations to make the most efficient use of front-end loaders used by the Navy.

CRAWLER-MOUNTED FRONT-END LOADER

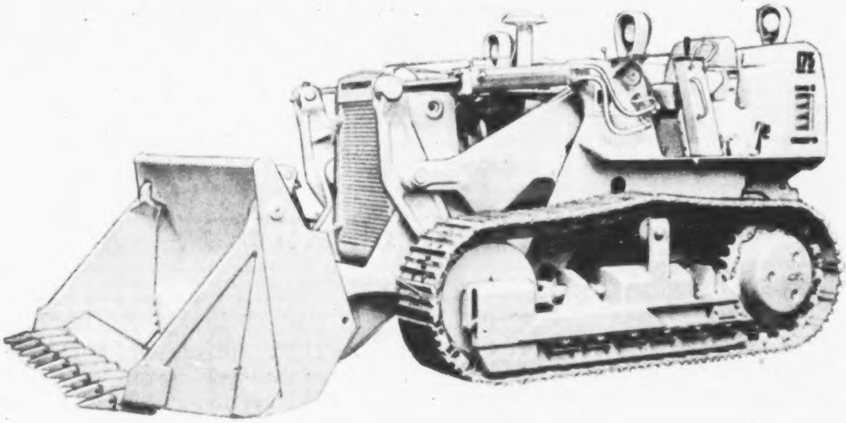
Mounted on crawler tracks, the front-end loader has a low ground bearing pressure which enables it to operate in areas that would be inaccessible to rubber-tired front-end loaders. The crawler-mounted front-end loader (fig. 10-1) has a relatively low speed which greatly decreases its mobility capability. However, crawler-mounted front-end loaders can be operated sideways on slopes of up to 35 percent and in-line with slopes of up to 60 percent. A hydraulic system provides positive control of the front-end loader. The crawler-mounted front-end loader normally has flat track pads (shoes) that allow it to work on firm ground with a minimum of damage to the surface.

RUBBER-TIRED FRONT-END LOADER

Mounted on large rubber tires, the rubber-tired front-end loader has a relatively low ground bearing pressure (45 pounds) that enables it to perform a large variety of jobs. The rubber-tired mounted front-end loader (fig. 10-2) can attain speeds up to 29 miles per hour, permitting good mobility from one jobsite to another. The power shift transmission with torque converter gives the front-end loader fast movement, both forward and reverse, with a minimum of shock and enables the machine to maintain a high rate of production. The large rubber tires provide good traction on unstable surfaces and allow the front-end loader to perform on side slopes of up to 15 percent and on straight slopes up to 30 percent in the direction of travel. The hydraulic system gives the operator positive control of the front-end loader and provides an assist in steering.

CAPABILITIES AND USES OF FRONT-END LOADERS

The front-end loader can travel in most cases from one construction site to another under its own power and does not require another item of equipment to level, smooth, or clean up an area in which it has been working. Typical uses of the front-end loader are backfilling excavations, loading trucks and other types of



29.64(115G)

Figure 10-1. — Crawler-mounted front-end loader.

hauling equipment, excavating and stockpiling materials, and lifting and moving construction materials. When equipped with rock-type tread tires the rubber-tired front-end loader can operate efficiently in and around rock quarries.

A front-end loader can dig excavations such as building foundations and other belowground areas if the material to be excavated is not too hard. In doing so, it must construct a ramp into the excavation in order to bring the material out. A combination of the front-end loader and haul trucks will increase job efficiency more than three-fold.

When using the front-end loader in backfilling operations on a hard-surfaced area such as asphalt you will find the rubber-tired tractor tires an advantage in that they have a minimum tearing effect. By lowering the bucket to ground level, the forward movement of the machine

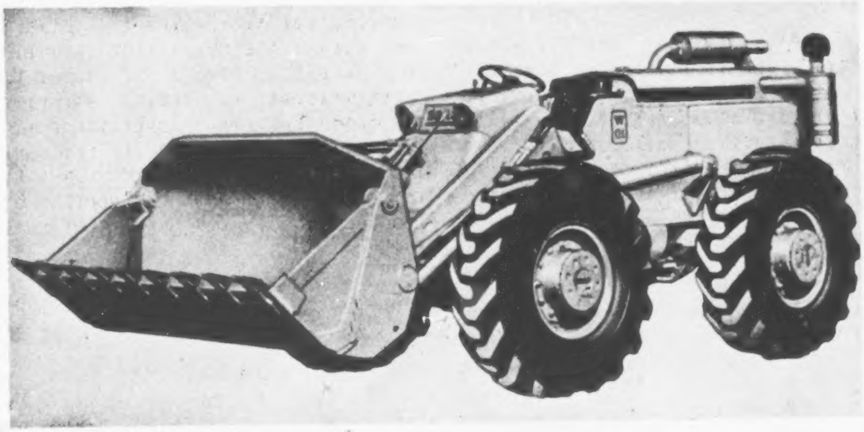


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Figure 10-2. — Rubber-tired front-end loader.

will push the stockpiled material into the excavation. This work is ideal for the front-end loader as long as the bucket is as wide or wider than the tracks or wheels of the tractor to ensure cleanup in the least number of passes. Narrow buckets cause the tracks or wheels to ride up on the stockpile which raises one corner of the bucket and reduces the area of cleanup.

When loading haul trucks with a front-end loader from a stockpile, have the trucks spotted at approximately a 30-degree angle from the stockpile. This allows the front-end loader to travel a minimum distance while remaining perpendicular to the pile when digging. Distance from the front-end loader to the truck should be varied according to the tractor size. Spotting the trucks too close to the front-end loader results in excessive maneuvering for the operator and decreases production.

Important considerations when sizing a front-end loader to truck sizes are (1) truck versus the bucket capacity, (2) truck body length versus the bucket length, (3) number of different truck sizes loaded per shift or day, and (4) the distance between stockpiles. Proper consideration of these factors results in increased production.

The front-end loader is often utilized on many miscellaneous tasks found in construction work such as stripping overburden; charging hopper and skips; carrying concrete to forms; lifting and moving construction materials, forms, large concrete and steel pipes; and assisting in plant erection and maintenance activities such as loading and off-loading small generators, water pumps, and engines. The loader is also utilized to tow small trailers and light loads.

The production of front-end loaders will be affected by numerous factors which must be considered prior to employment. Some of these factors are operator skill, density and compaction of the material, weight and volume of the material, slope of the operating area, height of the material, climatic conditions, and job priorities.

Assume, for purposes of this discussion, that you are truck loading from a stockpile. Matching the correct bucket size to the truck capacity is necessary. Thus, if high production is a prime consideration, a 2 1/2-cubic-yard front-end loader would be the smallest loader to use with 10-cubic-yard trucks. If a large number of trucks — 25 or more — are loaded per hour, one 5-cubic-yard loader may be more efficient than two 2 1/2-cubic-yard loaders.

Careful checking of actual loading time compared to the time spent traveling from stockpile to truck will best determine loader size selection when long travel distances are involved.

Remember, front-end loader speed is a primary factor to be considered in moving materials. Whether moving material from out of a bank or from a stockpile, significant operating economies are possible if the project has been laid out to take care of the loader's speed. The most practical grades for favorable downhill traveling range up to 33 percent and for uphill traveling up to 20 percent. Anything beyond these ranges deprives the loader of its speed advantage.

FRONT-END LOADER BUCKETS

Two types of front-end loader buckets are commonly used. One type is a general-purpose bucket, and the other a multi-segment bucket. Both types may be used on crawler or rubber-tired tractors. (See figs. 10-3 and 10-4.)

The general-purpose (or roll-back) bucket is a single-piece bucket constructed of heavy-duty, all-welded steel, with bolted or welded replaceable cutting edges. Also attached are bolt-on type replaceable teeth which provide for excavation of medium to hard type materials.

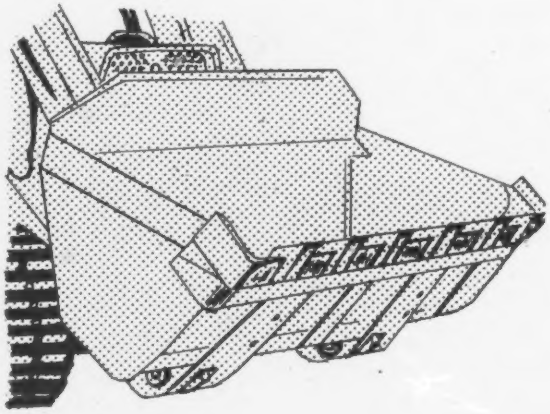

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Figure 10-3. — General-purpose (roll-back) bucket.

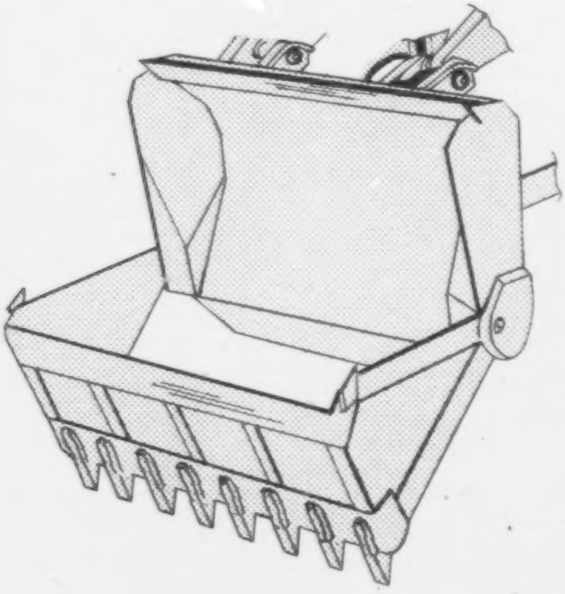

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Figure 10-4. — Multi-segment (4-in-1) bucket.

The multi-segment (or 4-in-1) bucket is also constructed of heavy-duty, all-welded steel, with bolted or welded replaceable cutting edges. This bucket also has attached bolt-on type replaceable teeth which provide for excavation of medium to hard type materials. In addition, the multi-segment bucket is of two-piece construction to provide capabilities not available in a general-purpose single-piece bucket. For instance, the multi-segment bucket can be utilized as a clamshell, dozer, scraper, and scoop shovel.

OPERATION OF FRONT-END LOADERS

The front-end loader bucket is attached to its prime mover by means of a push frame and hydraulic lift arms, and may be the conventional one-piece (general-purpose) type or the hinged-jaw (multi-segment) type. By manipulating the operating control levers, the bucket may be positioned for digging, lifting, hauling, and dumping.

When using the bucket, it is filled by moving the entire unit forward with the bucket at the desired digging level. When filled, the bucket is tilted upward to free it from the bank or stockpile. This upward position is maintained while backing away to prevent spillage. When the unit reaches the truck, the bucket is raised high enough to clear the truck body and dump the load. When the load has been dumped, the unit is backed away, the bucket is lowered to a carrying position and the unit returns to the jobsite.

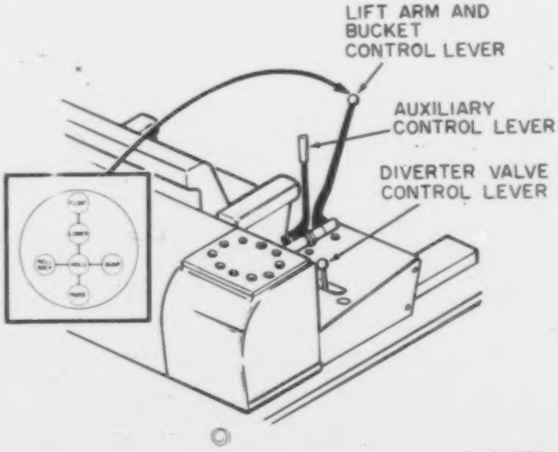
TECHNIQUES OF FRONT-END LOADER OPERATION

Figure 10-5 illustrates the lift arm and bucket control lever and positions which are: RAISE, HOLD, LOWER, FLOAT, DUMP, AND ROLL BACK. The positions of DUMP and ROLL BACK can be used simultaneously with any of the other four positions.

When the loader is equipped with the multi-segment (4-in-one) bucket, the auxiliary control lever (fig. 10-6) which controls the operation of any front mounted equipment and the diverter valve control lever (fig. 10-7) which permits a dual function of the auxiliary control lever are positioned as illustrated.

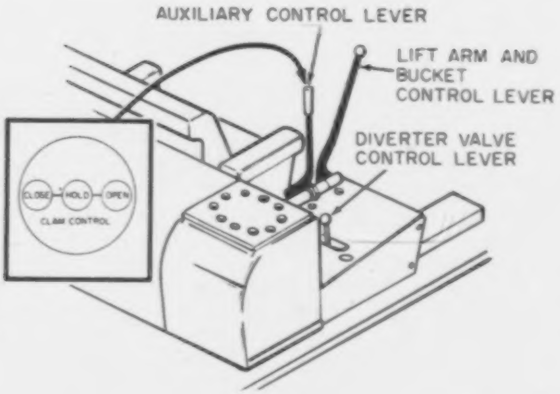
In addition to serving as a skid shovel, the multi-segment (4-in-1) bucket attachment can be used as a bulldozer, scraper, or clamshell.

For various operations, the position indicator and decal located on the right-hand tilt cylinder enable you to position the 4-in-1 bucket in any one of the positions mentioned below.

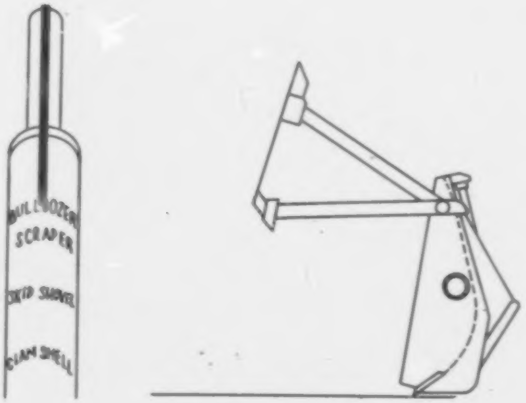

LIFT ARM AND BUCKET CONTROL LEVER
AUXILIARY CONTROL LEVER
DIVERTER VALVE CONTROL LEVER

115.464

Figure 10-5. — Lift arm and bucket control lever positions.


AUXILIARY CONTROL LEVER
LIFT ARM AND BUCKET CONTROL LEVER
DIVERTER VALVE CONTROL LEVER
CLOSE
HOLD
OPEN
CLAM CONTROL

115.465
Figure 10-6. — Auxiliary control lever positions for 4-in-1 bucket.



115.467
Figure 10-8. — Position indicator and bucket bulldozer position.

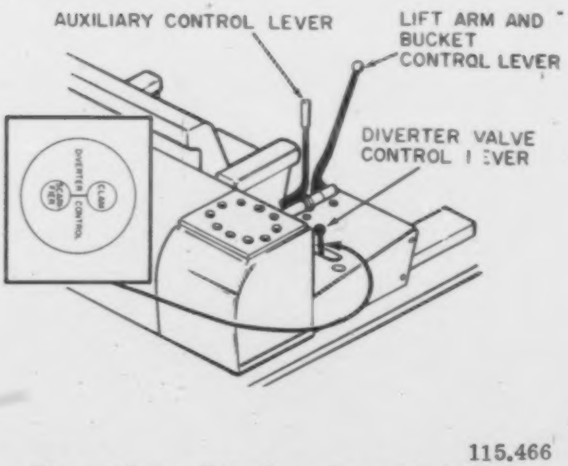
To use the bucket as a bulldozer, set the position indicator tip on the bulldozer position and open the clam as illustrated in figure 10-8.

To use the bucket as a scraper, set the position indicator tip on the scraper position and open the clam slightly as illustrated in figure 10-9.

To use the bucket as a skid shovel, set the position indicator tip on the skid shovel position and keep the clam closed as illustrated in figure 10-10.

To use the bucket as a clamshell, set the position indicator tip on the clamshell position and open the clam all the way as illustrated in figure 10-11.

The 4-in-1 bucket depth gage indicator (fig. 10-12) located on the upper left rear side of the bucket indicates the maximum amount of


AUXILIARY CONTROL LEVER
LIFT ARM AND BUCKET CONTROL LEVER
DIVERTER VALVE CONTROL LEVER
DIVERTER CONTROL
CLAM

115.466
Figure 10-7. — Diverter valve control lever positions.

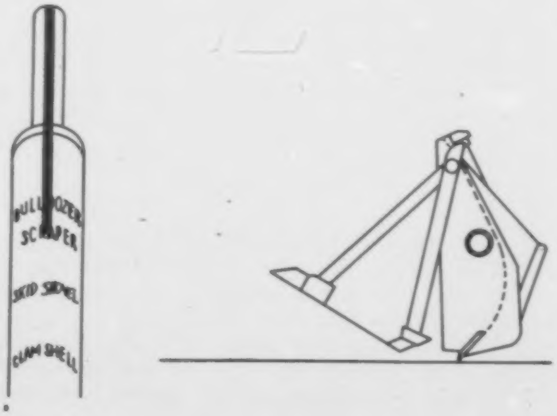


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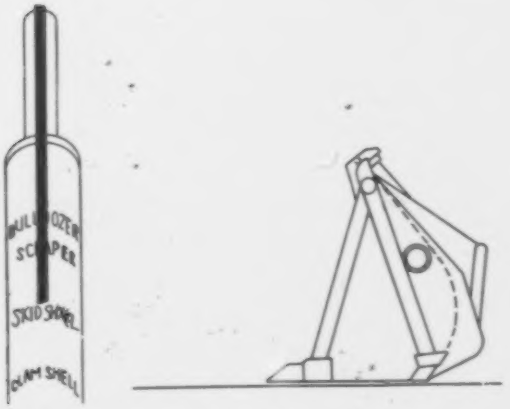
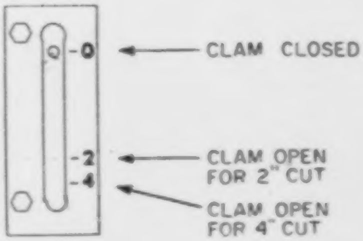
Figure 10-9. — Position indicator and bucket in scraper position.



115.469
Figure 10-10. — Position indicator and bucket in skid shovel position.

depth cut, which depends upon the clam opening. Use of this indicator will give you the inch-close depth cutting accuracy desired when using the 4-in-1 bucket in bulldozing or scraper operations.



115.471
Figure 10-12. — Depth gage indicator.

During loader operations the HYDRO SPRING (fig. 10-13) acts as a mechanical "shock absorber" for the hydraulic lift circuit. It is not connected to and has no effect on any of the other hydraulic circuits. The hydro spring reduces the "bounce" when transporting and the "shock" when driving or bumping into hard objects. When greater prying forces are required or when finish grading where rigid control is needed, omit the hydro spring by closing the hydro spring valve.

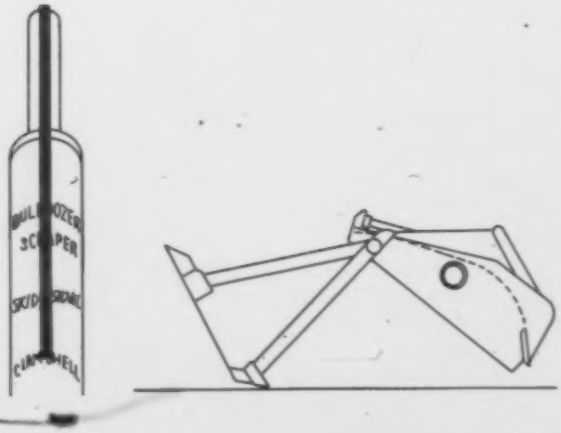


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Figure 10-11. — Position indicator and bucket in clamshell position.

In operating the loader, start all jobs, when possible, from relatively level ground. If necessary, level an area large enough to provide sufficient working space for the loader. This prevents back-and-forth pitching of the loader and will result in easier digging.

Avoid track spinning whenever possible; track spinning wastes effort and only converts a

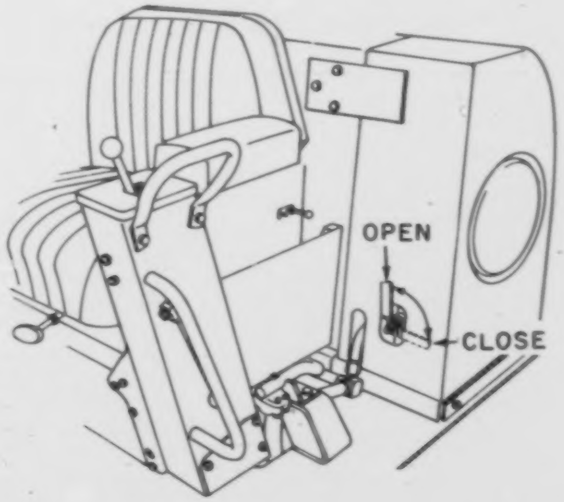

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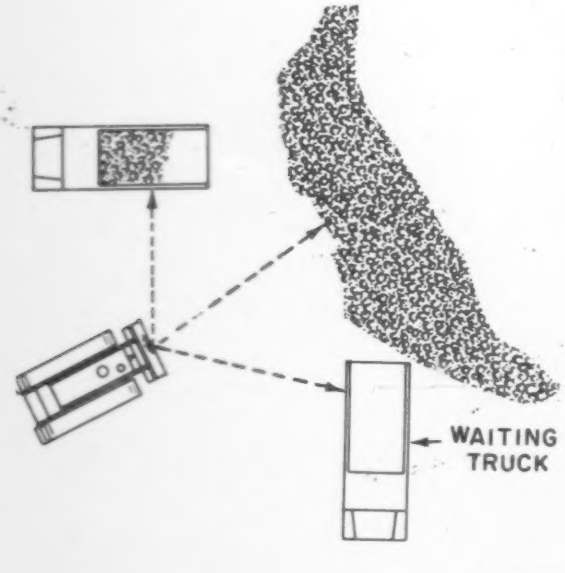
Figure 10-13. — Hydro spring valve positions.



115.473
Figure 10-14.—Loading from bank or stockpile.

relatively smooth working area into ruts and piles of material that pitch and tilt a loader. In cold weather this material will freeze and cause difficulty in handling the following work day.

Crossing ditches, ridges, rocks or logs should be done slowly and, if possible, at an angle. This procedure slows the fall, lessens the danger of upsetting the loader, and reduces the fall jolt which can be harmful to both the operator and loader.

When handling heavy loads or working on rough terrain, it is recommended that the counterweight attachment be installed on the rear of the loader to counterbalance the loader bucket.

When loading from a bank or stockpile, use the method shown in figure 10-14. Keep the trucks close to the work area to minimize loader travel. Keep work areas clean and level. When possible, spot the next truck to be loaded on the opposite side as shown in figure 10-14.

Approach the bank or stockpile with the engine at full governed speed. Keep the bucket flat, working into the material at or near ground level. As the bucket penetrates the material, raise the bucket slightly. When the material boils to the top of the spillboard, roll the bucket all the way back as shown in figure 10-15.

Raise the bucket to provide ground clearance and, at the same time, disengage the forward travel of the loader. Back away in an arc from the bank or stockpile as shown in figure 10-14, just far enough to allow turning of the loader for the approach to the truck.

When transporting material, raise the lift arm to give the same ground clearance as provided by the loader. A loaded bucket must never be transported in the fully raised position. Keep the travel speed reasonable for safe operation. Upon reaching the truck, raise the bucket high enough to clear the truck body. Reduce forward speed and dump the load as shown in figure 10-16. Shake the bucket only to loosen dirt from within.

When the load is dumped, back away, lower the bucket to carrying position, and return to the jobsite.

When bank loading, keep the cutting edge flat as shown in figure 10-17. Tilting the bucket back too far will force that flat of the cutting edge against the bank and prevent the bucket from digging. This nonproductive maneuver causes waste of power, time, and possible damage to the tilt cylinders and linkage.

When stockpiling, move each load only once and keep travel distance at a minimum. When possible, locate stockpiles as close as possible without hindering other work at the site.

Plan excavating jobs so most of the work can be done with the loader being driven forward out of the excavation, rather than being backed out. Use as flat a ramp as possible. A steeper ramp can be used when driving forward than when in reverse.

Always feed the bucket into the ground gradually until the desired depth of cut is obtained. when selecting gear range and determining the depth of cut, allow for an increase in resistance as the load increases. It may be necessary to raise the lift arms slightly to obtain greater traction.

When clearing a rocky area, remove the small and loose rocks first. Large rocks and other solid objects can then be loosened and moved with less difficulty.

When loosening large rocks or other solid objects, greater force and penetration can be obtained by digging under the rock with the bucket as shown in figure 10-18. Lifting the rock with the bucket while pushing will increase traction and reduce track spinning.

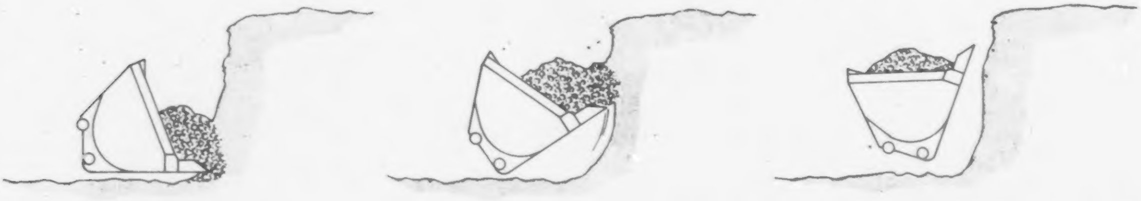


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Figure 10-15.— Filling the bucket.

When finishing in non-solid materials, position the bucket as shown in view A or B or figure 10-19, and backdrag the loose material. This method is not recommended where abrasive material is encountered.

By placing the bucket in the scraper position and opening the clam slightly, spreading of material can be done on the "run." The amount of spread can be controlled by the amount of the clam opening as shown in figure 10-20. With the clam fully open, the bucket can be used to bulldoze material. For level grading of material, position the bucket as indicated in view A, figure 10-21. To spread or obtain a lesser cut in material, position the bucket as illustrated in view B, figure 10-21.

HAND SIGNALS

A uniform system of hand signals must be used in all front-end loader operations of a similar nature. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be located so as to be clearly visible to the operator at all times. Hand signals used in front-end loader operations are depicted in appendix I. It is important that you not only recognize and understand these hand signals when operating equipment, but also be

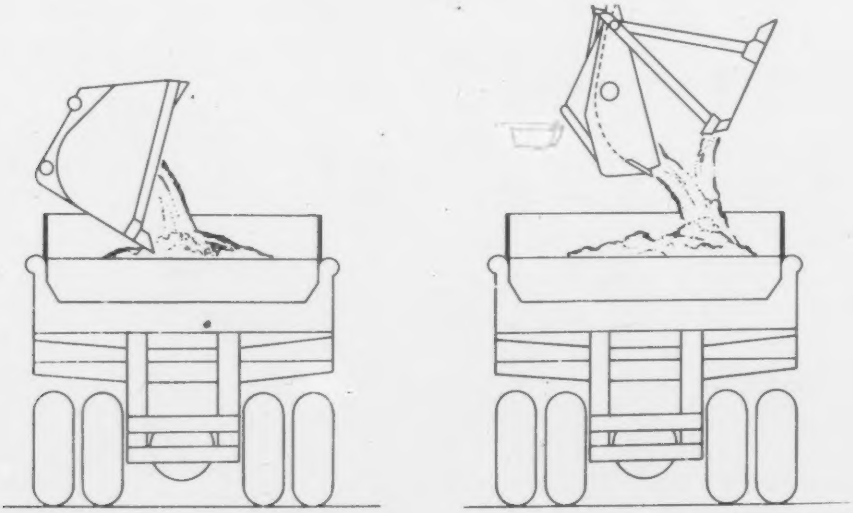

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Figure 10-16.— Loading trucks in proper manner.

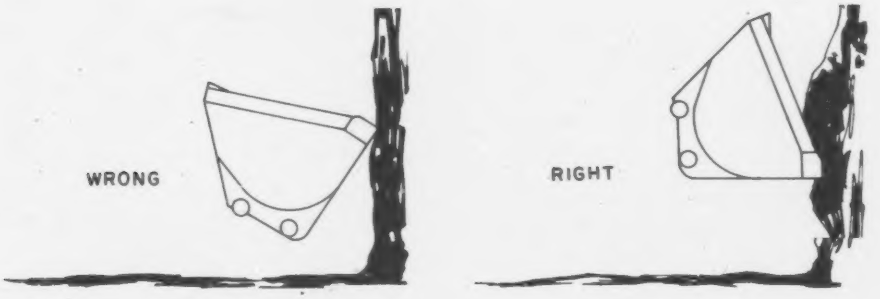

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Figure 10-17. — Bucket positioning for bank loading.

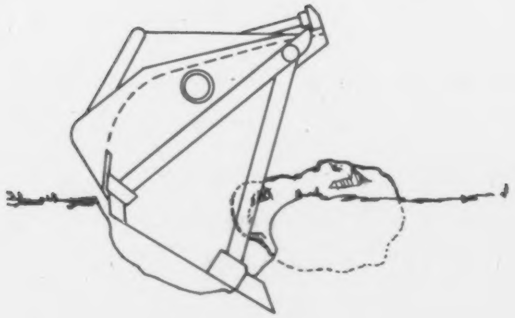

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Figure 10-18. — Bucket positioning for clearing rocks or other solid objects.

able to give them when called upon to act as a signalman on a construction project.

SECURING

Before securing a crawler-mounted front-end loader, position the bucket for traveling, drive the loader to the designated securing area, and position the loader in a safe manner. After the machine has stopped, lower the bucket to the ground, set the handbrake, place the transmission in neutral position, allow the engine to throttle down to slow idle (no load) for 3 to 5 minutes, and then move the engine speed control lever to the shut-off position to stop the engine. After the engine stops, place the electrical system master switch to the "OFF" position.

Before securing a rubber-tired front-end loader, position the bucket for traveling, drive the loader to the designated securing area, and position the loader in a safe manner. After

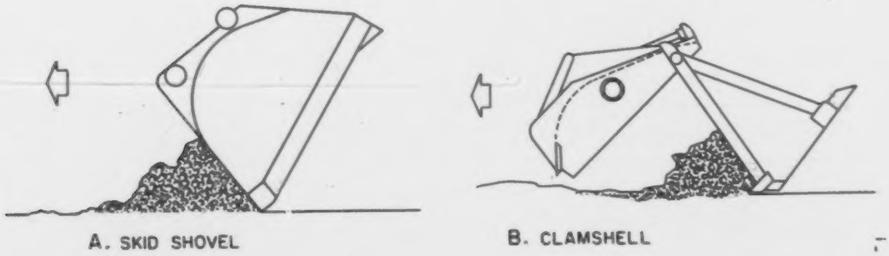

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Figure 10-19. — Bucket positioning for backdragging non-solid materials.

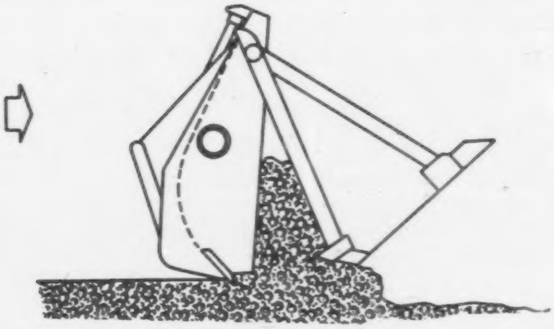

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Figure 10-20. — Positioning the bucket for spreading material on the "run."

parking the loader, lower the bucket to the ground, set the parking brake hand lever, shift all controls to neutral, allow the engine to run at half speed or less for a few minutes, and then pull the fuel stop lever up to stop the engine. After the engine stops, turn the key switch counterclockwise to the OFF position.

OPERATOR'S MAINTENANCE

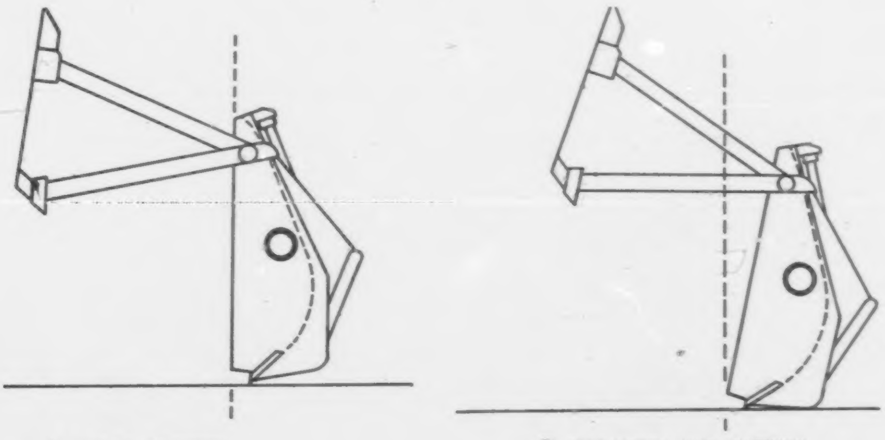
Every Equipment Operator is required to perform certain daily maintenance services on the front-end loader he operates. The faithful performance of these services does much to prolong the life of the front-end loader, to avoid major repairs and overhaul, and to assure the Equipment Operator that his equipment will perform its mission consistently and dependably.

INSPECTION

The procedures used in an operator's maintenance inspection of the various components of front-end loaders are the same as described in previous portions of this manual for automotive vehicles, materials-handling equipment, and tractors; thus, the procedures need not be repeated here.

LUBRICATION

The life and performance of a front-end loader depends on the care that it is given. Proper lubrication, performed at definite intervals, will aid greatly in prolonging the life of the loader and in reducing operating expense. The type of work being done, loads being handled, and ground and weather conditions are all factors to consider in determining the frequency of lubrication. It may be necessary to lubricate more frequently when working under severe operating conditions; such as heavy dust, low



A. LEVEL GRADING

B. SPREADING AND CUTTING

115.480

Figure 10-21. — Bulldozer position of loader bucket.

engine temperature, intermittent operation, excessively heavy loads with high oil temperatures, or when diesel fuel with a high sulphur content is used. However, the time intervals between lubrication periods must never exceed those indicated on the lubrication chart of the maintenance manual for the piece of equipment you are operating.

ADJUSTMENTS

Adjustment procedures for fan belts, hand-operated parking brakes, and tracks used on front-end loaders which would normally be made by the EO, are basically the same as given in chapters 5 and 9 of this manual for automotive vehicles and tractors and attachments, and need not be repeated here.

SAFETY

Some Safety precautions applying to front-end loaders are as follows:

1. Clear the immediate area of personnel of obstructions before starting the engine.
2. Keep the bucket as close to ground level as possible when transporting loads on grades or slopes.
3. Never operate any of the controls from any position except in the operator's seat.
4. Be extra careful when working on banks or hillsides.
5. Always keep machine in gear when going down steep grades.
6. Drive at speeds slow enough to ensure safety and complete control, especially over rough terrain.
7. Reduce speed when making turns or applying brakes.
8. Never leave the engine running while the loader is unattended.
9. Always lower the loader lift arms to the ground or block them securely before performing any service or when leaving the machine unattended.
10. Never dismount the loader when it is in motion.
11. Never permit persons other than the operator to ride on the loader.
12. Do not oil, lubricate, or adjust the loader when the engine is running or the bucket is raised and unblocked.
13. Never refuel the loader when the engine is running.
14. DO NOT smoke when refueling the loader.
15. Never operate the loader in a closed area; provide proper ventilation.
16. Do not wear loose fitting clothing which may catch in moving parts of the loader.

CHAPTER 11

POWER CRANES AND ATTACHMENTS

Cranes, one of the basic tools of earthmoving, first made their appearance about 1835 in the form of a part swing dipper shovel, mounted on flat cars and moved over railroad tracks. Although the crane, powered by steam, was slow and clumsy, it did work. Over the years, cranes gradually acquired a variety of attachments and left the rails to appear on crawler tracks and rubber tires.

The modern crane and attachments constitute a versatile and important piece of equipment which can be used on most types of building, road, and airstrip construction under varying conditions.

General information on the operation, maintenance capabilities and utilization of cranes is presented in this chapter. Step-by-step procedures are given for changing and adapting cable/hydraulic assemblies on crawler-, truck-, and wheel-mounted cranes. The characteristics, construction, and usage of wire are discussed, as well as the use of slings, spreaders, pallets, cargo nets, and hooks. In addition, safety precautions to be observed when operating or working near power cranes are noted throughout the chapter.

TYPES AND USES OF POWER CRANES

Cranes and attachments are designed primarily to ensure the performance of weightlifting and excavating operations under varied conditions. To make the most efficient use of cranes and attachments, it is important that the EO recognize their capabilities and limitations.

Although the superstructure is about the same on all makes and models of power cranes, the carrier or mounting may be one of three types: crawler, truck, or wheel (fig. 11-1). In order to make the basic unit complete and operable, any one of six attachments may be installed: hookblock, clamshell, dragline, shovel, backhoe, or piledriver (fig. 11-2). Once an attachment is installed, the entire unit acquires the name of that attachment.

CRAWLER-MOUNTED POWER CRANES

The crawler-mounted power (gas or diesel) crane is perhaps the most basic of the power

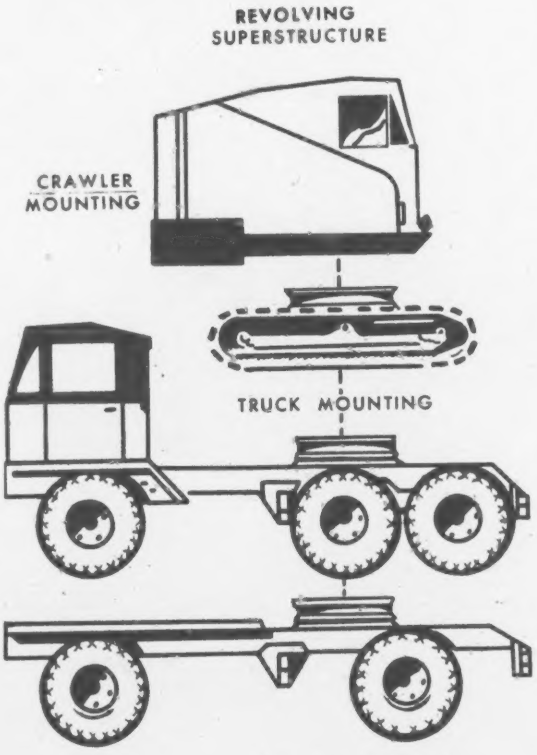


Figure 11-1.—Mounting for the power crane. 115.201

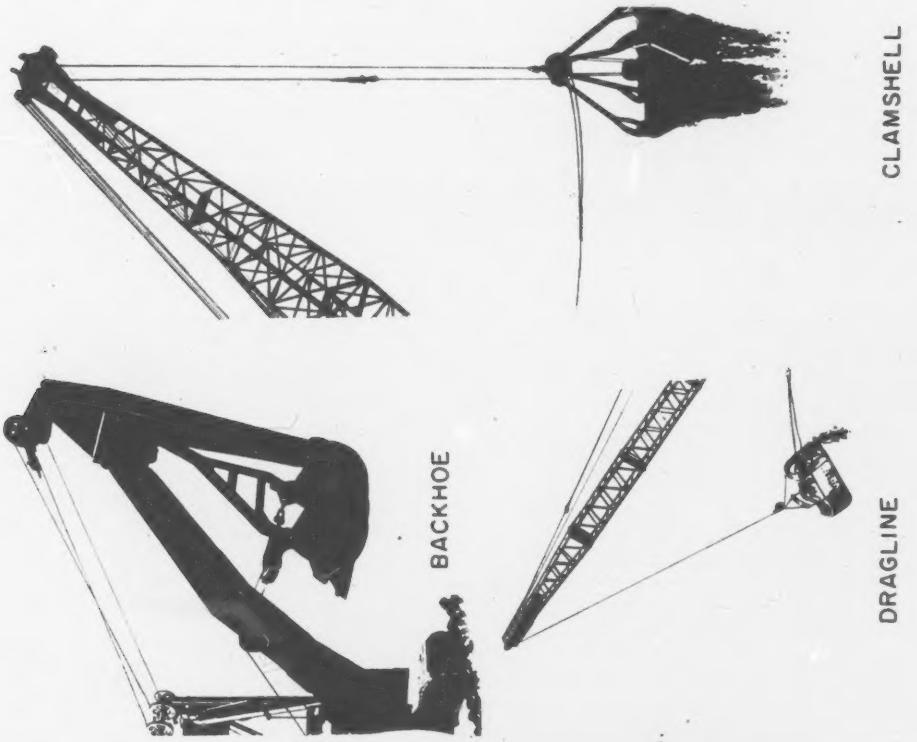


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Figure 11-2.—Power crane attachments.

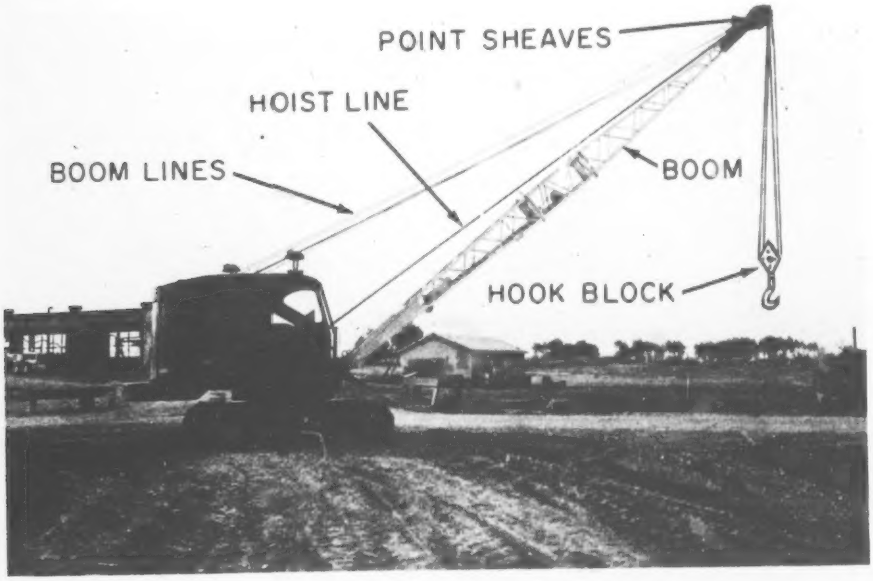

Figure 11-3. — Crawler power crane. 29.69

cranes (see fig. 11-3.) While slow and cumbersome in comparison to the truck-mounted power crane, the crawler crane is an easy machine to operate. The crawler crane provides a stable base for operation of the revolving superstructure.

The travel unit of the crawler crane is shown in figure 11-4. The unit includes the base, travel gears, clutches, travel brakes, sprockets, rollers, roller chains, and crawler treads.

The upper revolving unit of the crawler crane (fig. 11-5) consists of the engine, controls,

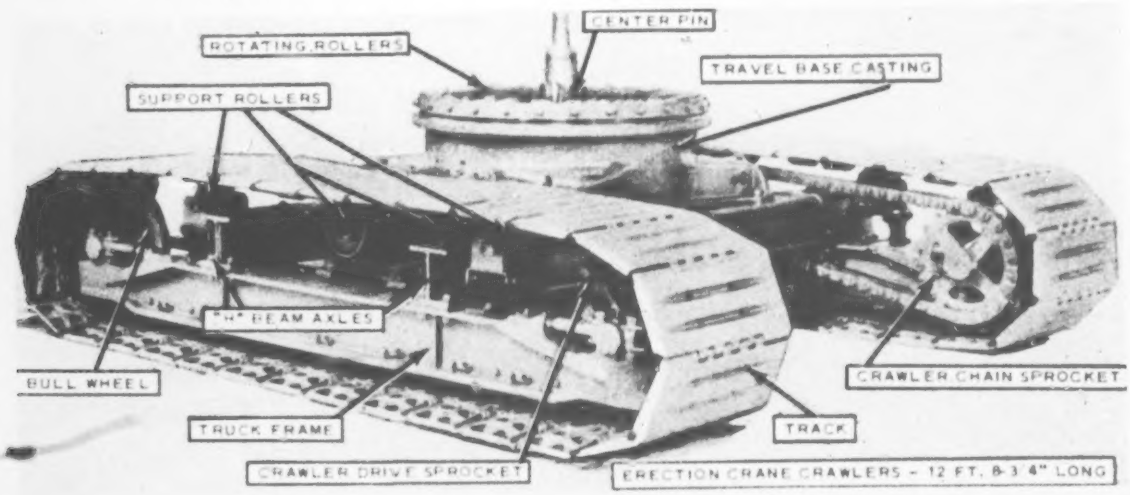

Figure 11-4. — Crawler crane travel unit. 115.276X

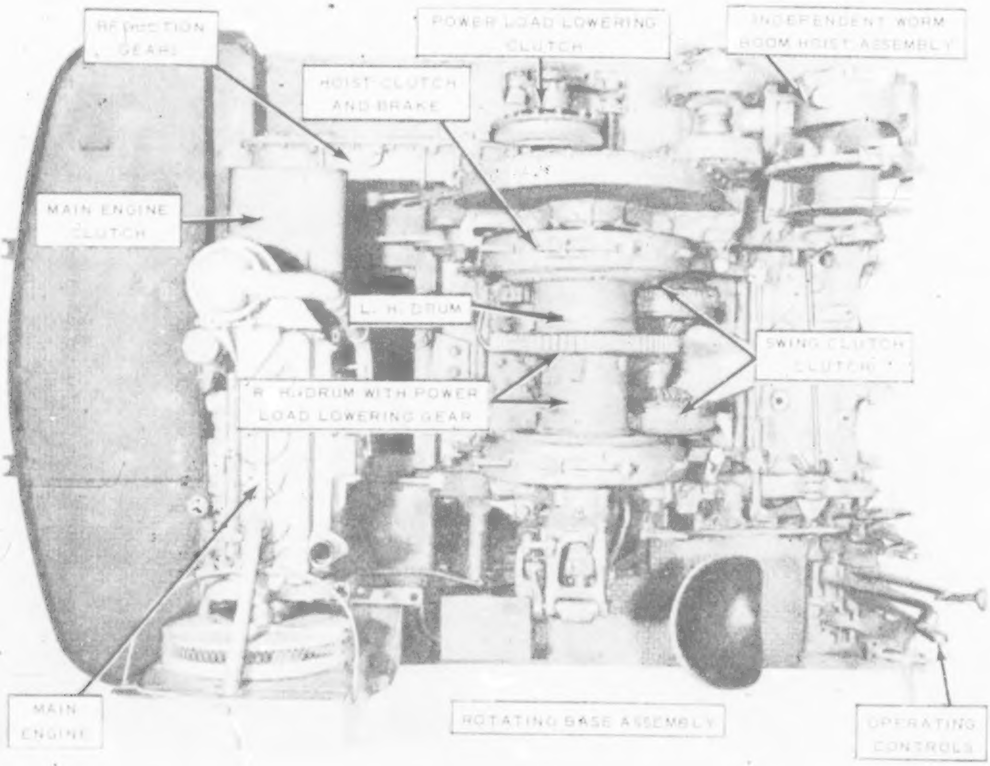

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Figure 11-5. — Crawler crane upper revolving unit.

cable drums, operator's cab, and counterweights. The basic upper revolving unit is supported by rollers running in a circular track or turntable. The turntable (fig. 11-6) is rotated by the vertical shaft and gear.

The crawler crane has a decided advantage over the truck-mounted crane, especially on continuous work in remote areas which are not readily accessible to truck-mounted cranes due to terrain conditions. Crawler steering with positive traction permits travel and turn without cutting up the work area or roadways.

The weight of the machine is spread over a large area due to the size of the crawler treads. This feature gives the crawler crane a ground bearing pressure of 5 to 12 psi, which enables it to travel over soft terrain. However, when climbing grades, the maximum grade capability is 30 percent on firm dry material. Crawler cranes have a radius of approximately the length of the tracks and speeds ranging from 1/2 to 2 miles per hour. The speed is one factor that limits the crawler crane's travel range, and it is recommended that the travel distance not exceed 1 mile. When the travel distance exceeds 1 mile, the crawler crane should be loaded on an equipment trailer for transportation.

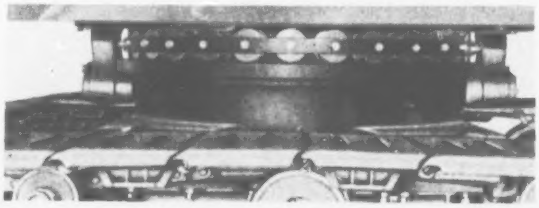

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Figure 11-6. —Crawler crane turntable assembly.

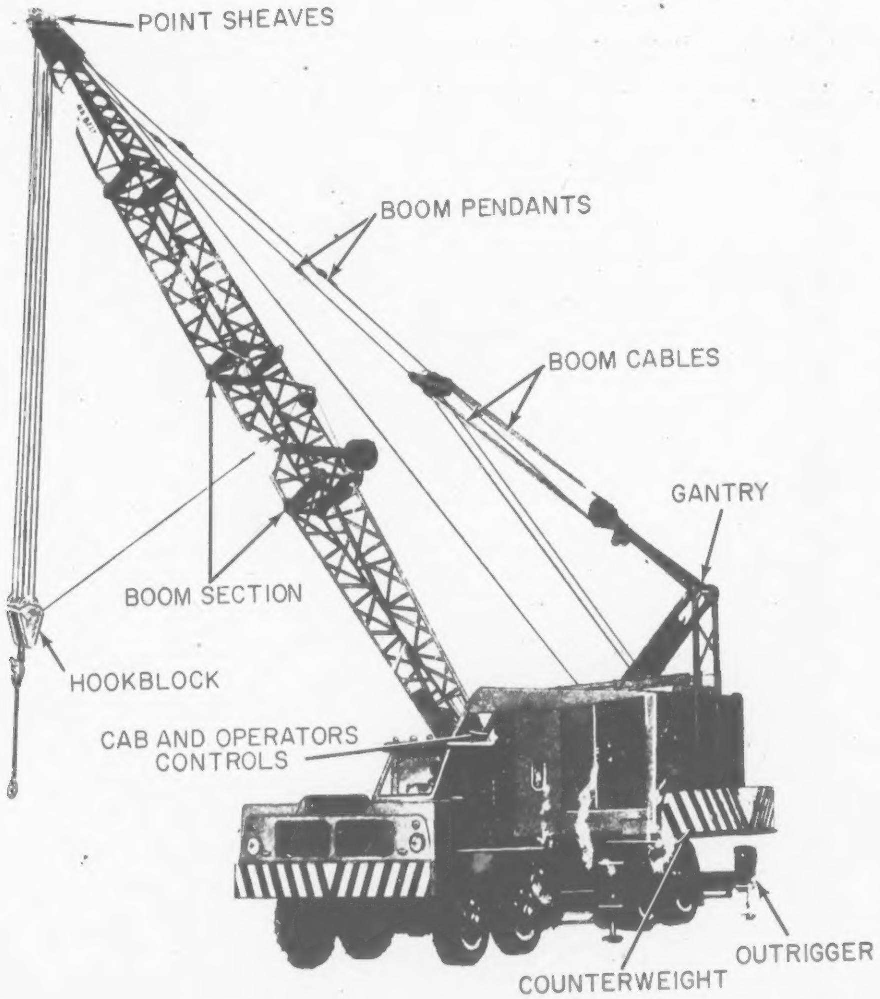

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Figure 11-7.— Truck-mounted power crane.

In soft terrain, the large bearing area of the crawler tracks ensures proper movement and stability. When working on hard footing such as that found in quarry operations, the crawler crane shows great stability. The crawler crane is better suited to quarry operations than truck-mounted cranes since the sharp rock fragments present in quarries would be detrimental to the truck's rubber tires.

On-the-job moves can be made with ease as long as they are relatively short. Job maneuverability is increased further by the crane's small turning radius. Cleats or grousers may be fabricated to increase traction in extremely soft or slippery material.

TRUCK-MOUNTED POWER CRANES

The truck-mounted crane (fig. 11-7) consists of a truck carrier and upper revolving unit. The truck crane's upper revolving unit can be locked in traveling position and moved along the highway at 20 to 35 miles per hour. This is a pleasant contrast to the slow and laborious job

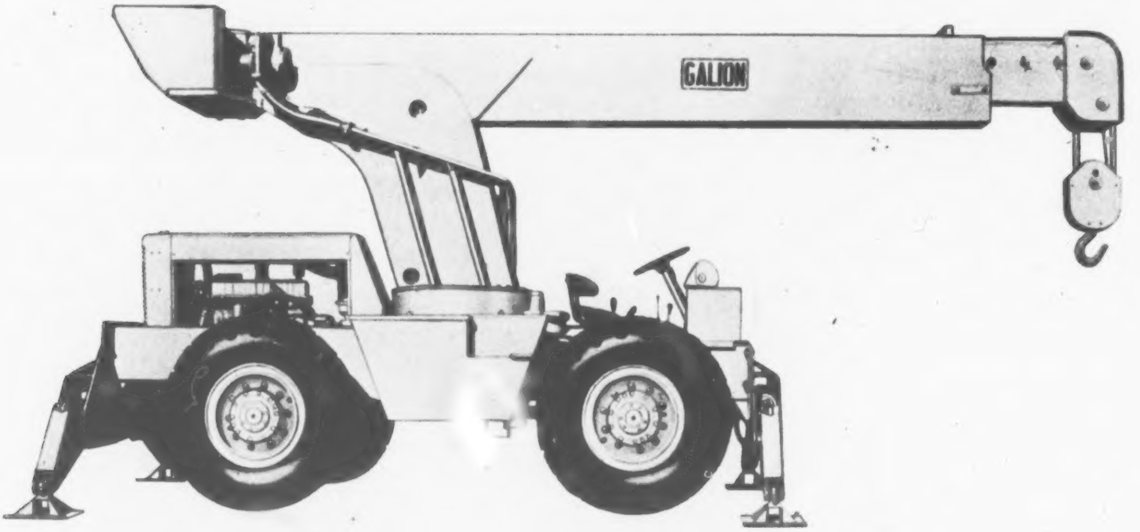

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Figure 11-8. — Wheel-mounted power crane.

of loading and securing a crawler-mounted crane on a low-bed trailer to move it from one jobsite to another and then having to unload it.

The truck crane has a high ground bearing pressure, which ranges from 75 to 100 psi, due to the pneumatic tires on which the machine travels. On firm dry earth, the truck crane can negotiate a 40 percent grade, whereas, the turning radius is in excess of 50 feet; for some models, the turning radius may be as high as 89 feet. The large turning radius greatly limits its maneuverability. The travel range of the truck crane is approximately 250 miles.

To prevent damage to the truck frame and tires, the use of the truck crane should be limited to firm, level terrain, or footings. Under normal operations, the truck crane is used on jobs of short duration; this is a rule because one does not tie up a highly mobile crane on jobs of long duration.

The truck crane requires two operations, one to move the machine and the other to operate the upper revolving unit with its attachment. By towing a trailer, the truck crane can carry all the basic attachments needed to the jobsite.

WHEEL-MOUNTED POWER CRANES

The wheel-mounted power crane (fig. 11-8) is a hydraulically operated crane consisting essentially of a 4-wheel-drive, 4-wheel-steering, pneumatic-tired, diesel-engine-powered carrier, with a center-mounted telescopic boom.

The major superstructure of the wheel-mounted crane consists of the following components: a telescoping boom, a single-acting hydraulic lift cylinder, a hydraulically operated cable winch, hydraulic outriggers, and a hook-block attachment.

The wheel-mounted crane has a ground bearing pressure of approximately 35 psi. The machine can travel at speeds ranging from 2 to 30 mph. The wheel-mounted crane can turn in a 30-foot radius using two-wheel steering, and a 17-foot radius using four-wheel steering. It can also negotiate a grade of 40 percent on firm, dry terrain.

Factors involving the use of the wheel-mounted crane are similar to those of the truck-mounted crane. The wheel-mounted crane is well adapted for delivery to job locations. The crane can be driven on roads or off roads over rough terrain.

The wheel-mounted crane is a highly mobile and very flexible machine. This makes its use

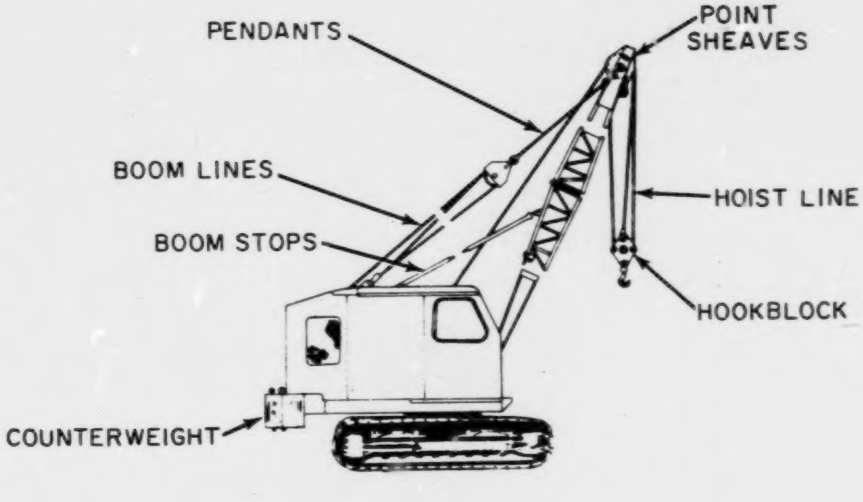

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Figure 11-9. — Crane with hookblock attachment.

desirable for a wide range of operations regardless of location—on or off the road. These operations include lifting and carrying loads of every shape and size; positioning heavy components; installing pipes, tanks, etc., below grade; reaching inside trucks and boxcars; handling, stacking, and stockpiling materials.

CRANE RATINGS

Crawler-mounted cranes are rated at not more than 75 percent of the minimum load which causes tipping at any specified radius with the standard boom in the least stable position. Thus, the 10- and 40-ton crawler-mounted cranes are capable of lifting a "maximum safe" load of 10 and 40 tons, respectively, at a "minimum safe" operating radius of approximately 12 feet.

Truck- and wheel-mounted cranes are rated at not more than 85 percent of the load which will cause tipping at a 10-foot operating radius with outriggers employed over the rear or front of the mount. Therefore, a truck- or wheel-mounted crane rated at 20-ton capacity is capable of lifting a "maximum safe" load at a "minimum safe" operating radius of 10 feet with the standard boom length.

Before making a lift, consult the tables furnished with the machine concerning the recommeded radii and boom lengths required when handling specific weights of materials.

CRANE ATTACHMENTS

A variety of front-end attachments and mountings are required for cranes because no one type of boom, size of machine, or mounting is suitable for every type of job. The advantages and usual limits of application for each type of crane front-end attachment are described in the following sections.

HOOKBLOCK (CRANE)

A crane equipped with a hookblock (fig. 11-9) is used for lifting an object or load, transferring it to a new location by swinging or traveling, and then placing it. Incidentally, a crane with a hookblock is commonly referred to simply as a crane.

The basic crane equipment consists of a crane (lattice type) boom, hoisting drums or lagging for desired line pulls and speeds, hookblock to provide the required parts of line reeving), and the boom suspension and hoist wire ropes.

The crane boom is usually made in two sections, fastened approximately in the center by one of two methods: bolted butt plate (flange) connections or pin and clevis connections. The upper section with the boom head and a system of sheaves (usually two or more) is not necessarily the same length as the lower section.

MAXIMUM ALLOWABLE LOADS — CRANE SERVICE								
Boom Length In Feet	Load Radius In Feet	Boom Angle In Degrees	Boom Point Pin Height	With Outriggers Set†		Without Outriggers		
				Over Side	Over Rear**	Over Side		Over Rear
						8'-0" Wide	9'-0" Wide	8' or 9' Wide
30	10	78	35'6"	*50,000	*50,000	28,800	32,200	39,300
	12	74	35'0"	*50,000	*50,000	22,500	24,900	30,800
	15	68	34'0"	*50,000	*50,000	16,800	18,500	23,200
	20	57	31'3"	36,800	*43,700	11,700	12,800	16,200
	25	44	27'3"	26,000	31,100	8,800	9,700	12,400
40	12	78	45'3"	*50,000	*50,000	22,200	24,600	30,600
	15	74	44'6"	*50,000	*50,000	16,500	18,200	22,900
	20	66	42'9"	36,600	*41,300	11,400	12,500	16,000
	25	58	40'0"	25,800	30,900	8,600	9,400	12,200
	30	49	36'3"	19,800	23,700	6,800	7,400	9,700
	35	38	30'9"	15,900	19,100	5,500	6,050	8,000
50	15	77	55'0"	*50,000	*50,000	16,400	18,000	22,700
	20	71	53'6"	36,500	*40,000	11,300	12,300	15,800
	25	65	51'6"	25,700	*30,400	8,450	9,250	12,000
	30	58	48'9"	19,600	23,600	6,650	7,250	9,500
	35	51	45'0"	15,800	19,000	5,400	5,900	7,800
	40	43	40'6"	13,100	16,800	4,500	4,900	6,600
	45	34	34'0"	11,200	13,500	3,800	4,150	5,650
60	15	79	65'3"	*48,800	*48,800	16,100	17,800	22,500
	20	74	64'0"	36,400	*39,100	11,000	12,100	15,600
	25	69	62'3"	25,500	*29,600	8,150	8,950	11,800
	30	64	60'0"	19,500	23,400	6,350	7,000	9,300
	35	59	57'3"	15,600	18,800	5,100	5,650	7,600
	40	53	53'9"	13,000	15,700	4,200	4,650	6,400
	45	46	49'6"	11,000	13,300	3,[illegible]	3,900	5,350
	50	39	44'3"	9,500	11,600	2,450	3,300	4,700
	55	32	37'9"	8,400	10,200	2,500	2,800	4,000
70	20	77	74'3"	36,200	*37,300	10,700	11,800	15,400
	25	72	73'0"	25,300	*28,800	7,850	8,700	11,400
	30	68	71'0"	19,300	*23,100	6,100	6,700	9,100
	40	59	66'0"	12,800	15,500	3,900	4,350	6,200
	50	49	58'6"	9,350	11,400	2,700	3,000	4,500
	60	36	47'6"	7,200	8,850	1,850	2,150	3,350
80	20	78	84'6"	*32,800	*32,800			
	25	75	83'3"	25,200	*28,400			
	30	71	81'9"	19,100	*22,600			
	40	63	77'6"	12,600	15,300			
	50	55	71'3"	9,200	11,200			
	60	45	62'9"	7,050	8,700			
	70	34	50'9"	5,600	6,950			
90	20	80	94'9"	*29,000	*29,000			
	25	77	93'9"	25,100	*26,000			
	30	73	92'3"	19,000	*22,200			
	40	66	86'6"	12,500	15,200			
	50	59	83'3"	9,050	11,000			
	60	51	76'3"	6,900	8,550			
	70	43	66'9"	5,450	6,800			
	80	32	53'6"	4,400	5,600			
100	20	81	105'0"	*25,300	*25,300			
	30	75	102'9"	18,800	*20,500			
	40	69	99'3"	12,300	15,000			
	50	63	94'9"	8,850	10,800			
	60	56	88'9"	6,700	8,400			
	70	49	81'0"	5,250	6,600			
	80	40	70'6"	4,200	5,350			
	90	30	56'3"	3,350	4,400			
110	20	81	115'0"	*22,000	*22,000			
	30	76	113'0"	*17,700	*17,700			
	40	71	110'0"	12,100	*14,000			
	50	65	106'0"	8,650	10,700			
	60	59	100'6"	6,500	8,200			
	70	53	93'9"	5,050	6,450			
	80	46	85'3"	4,000	5,200			
	90	38	74'3"	3,200	4,250			
	100	29	59'0"	2,600	3,500			

115.493

Figure 11-10.—Typical crane capacity chart.

Incidentally, when the boom length exceeds the normal or standard length, as shown in figure 11-10, the crane's lifting capacity is reduced.

The crane boom can be increased by two methods. The most common method is by inserting intermediate center sections. The second method is by adding a boom tip extension, called a jib (fig. 11-11).

In general, when crane booms are lengthened, the gantry, or "A" frame, must be extended so that a sufficient lifting angle for the boom lines can be provided. Some cranes used by the SEABEES are equipped with stationary or non-adjustable gantries.

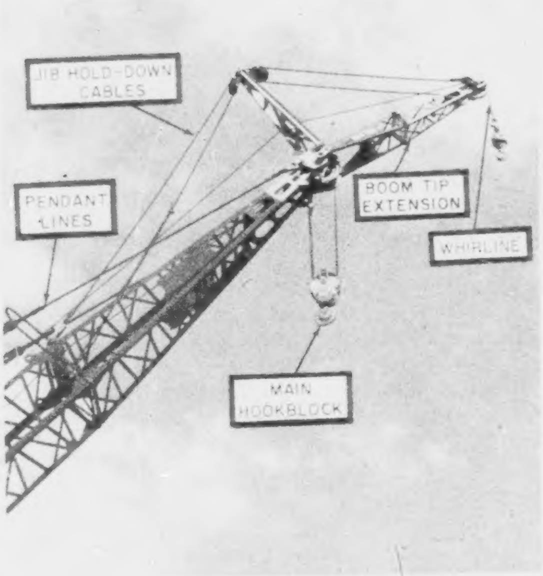
Special devices are available to prevent crane booms from going over backwards. Such devices consist of telescopic boom stops, cable anchor stops, or fixed stops to limit the backward free travel of the boom, boom hoist clutch, or engine clutch and throw-out linkage which permits the operator from accidentally pulling the boom over backwards by power.

The hookblock used on the crane should be of ample capacity to handle the maximum safe load. The safe working capacity (SWC) of a hook can be approximately by using the following rule of thumb: SWC (in tons) = D^2. The diameter (D) in inches of the hook is where the inside of the hook starts its arc. Thus, the safe working capacity of a hook with a diameter of 2 inches is as follows: SWC = D^2 = $(2)^2$ = 4 tons, or 8,000 pounds.

Tables of lifting capacities, posted inside the crane, usually do not include allowances for the weight of the hookblock being used. Therefore, the hookblock weight must be added into the overall weight being lifted.

CLAMSHELL

Like the crane, the clamshell (fig. 11-12) is a vertically operated attachment capable of working in three zones: at, above, and below ground level. Clamshell equipment consists of a crane-type boom, hoist drum laggings, clamshell bucket, tagline, and necessary wire ropes. The clamshell is capable of digging loose to medium type soils in all three zones, as well as dumping in any of the three zones. The height that can be reached by the clamshell is dependent on the length of the boom used, and the depth reached depends upon the length of the wire rope employed. The amount of wire rope that can be put on the cable drums is limited by the size of the drums and laggings.

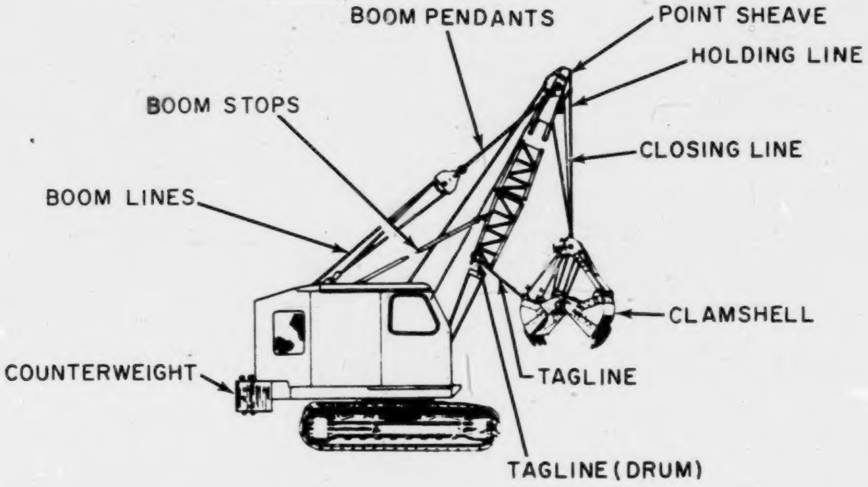


115.282

Figure 11-11. — Boom tip extension (jib).

The clamshell bucket (fig. 11-13) consists of two scoops hinged together. Each scoop includes a back bottom plate, side plates, lip, teeth, hinge, and arm brackets. One scoop is equipped with tagline attachments. Counterweights are bolted around the hinge. The bucket is controlled by the holding line, closing line, and tag line. There are three types of buckets, classified as Type I (light duty rehandling), Type II (general purpose), and Type III (heavy duty excavation). On most SEABEE projects, the Type II bucket, in sizes from 1/2-cubic yard to 2 1/2 cubic yard capacity, is generally used. Buckets with a capacity of 3 1/2 cubic yards are available for special units.

The tagline winder is a device used to control the tension on the tag line to prevent the clamshell bucket from twisting during operation. Some older machines use various devices, such as a heavy weight which slides or rolls up and down the boom, to control this twisting motion. The winder type of tagline shown in figure 11-14, however, is commonly used today. This type of tagline winder is interchangeable with any make or model of crane.



29.66

Figure 11-12.—Crane with clamshell attachment.

To obtain the safe working capacity for the clamshell, refer to the appropriate crane capacity table for the boom length and operating radius, then multiply the allowable load listed by 0.88. This reduces the allowable load to 2/3 of the tipping load for an additional safety factor.

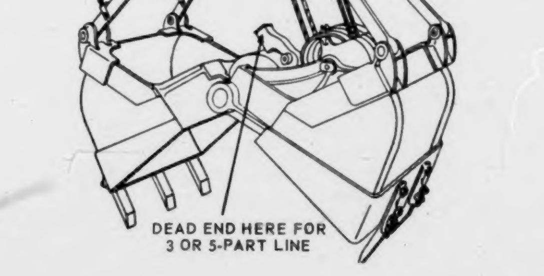

CLOSING LINE
HOLDING LINE
4-PART CLOSING LINE
DEAD END HERE FOR 2, 4 OR 6-PART LINE
SHACKLES FOR TAGLINE BRIDLE CHAIN
DEAD END HERE FOR 3 OR 5-PART LINE

Figure 11-13.—Clamshell bucket. 115.112

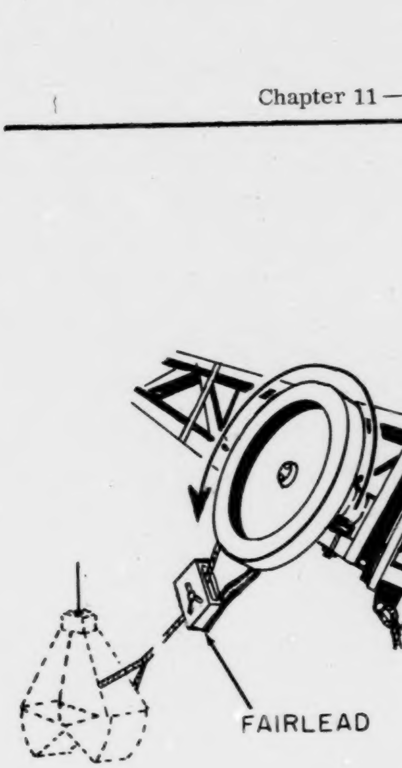
The drum laggings used on the clamshell may be the same type as those used for the crane or may be changed to meet the speed and pull required for effective operation. This requirement depends upon the design of the equipment, so the manufacturer's technical manual on the machine should be consulted.

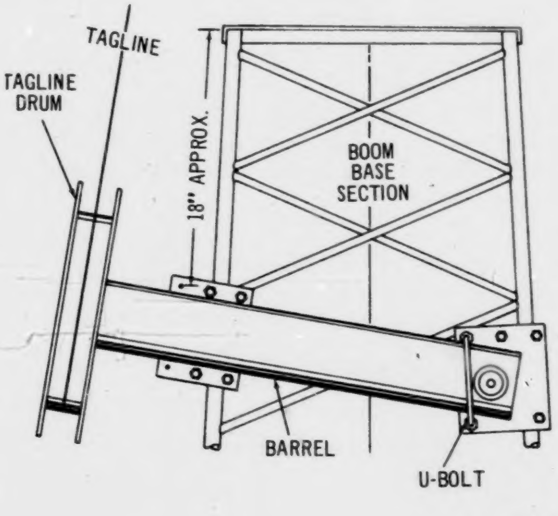
DRAGLINE

Draglines are best used for excavating loose materials below the working level of the machine. They are also used in underwater excavation. In digging operations, the dragline is used to dig dirt, shale, and well blasted rock. Such jobs include stripping overburden, digging borrow pits, and digging and cleaning drainage ditches. The dragline is capable of digging well below the ground level.

The dragline (fig. 11-15) consists of a crane-type boom, dragline bucket, fairlead assembly, and the necessary wire ropes. The fairlead accomplishes what its name implies—it "fairleads" the drag rope when it is wound in on the drum during loading operations of the dragline bucket.

In dumping operations, the dragline disposes of the excavated materials either by loading into haul units or by casting onto a spoil bank. (Either of these operations must be done by an experienced operator.) The casting method is used to build a levee or dike.





115.285
Figure 11-14.—Typical tagline winder.

Casting and dumping material as far as possible from the unit is accomplished by the dragline because of its long, low boom. When ditching in swampy areas (as may be required in malaria control ditching), large, rigid, timber mats are fabricated and fitted with lifting slings so that the operator can lift one mat and place it ahead of the crane when movement is necessary.

BACKHOE

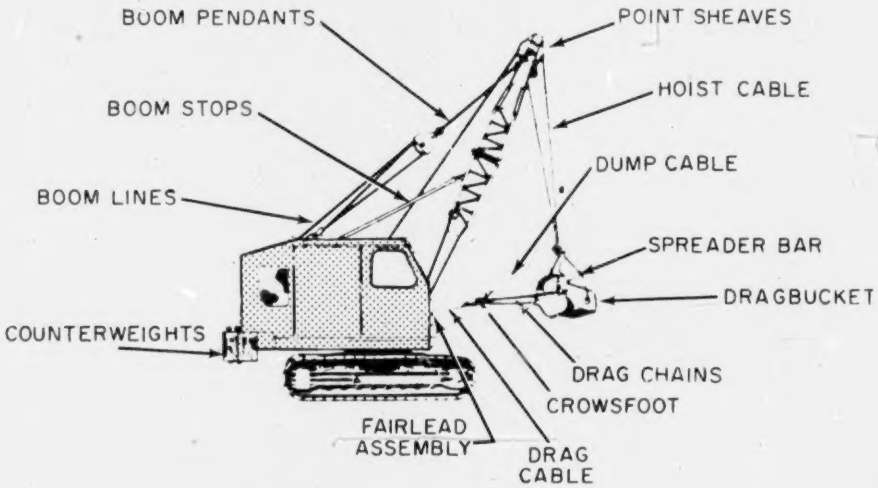
The backhoe (fig. 11-16) is a positive digging tool and incorporates some of the characteristics of both the shovel and the dragline. It is used primarily to dig below ground level. It will dig harder material than the dragline or clamshell, because the weight of the boom is used to force the dipper into the material. The backhoe is limited in digging depth by the length of the boom, the length of the stick, and the bucket size. The backhoe dipper can be controlled more accurately than the dragline bucket; therefore, it is better suited to close-limit work.

The attachment consists of five major components: dipper, dipper handle, box type boom, auxiliary A-frame, and a grooved drum lagging that is installed on the front drum for the dipper pull rope. Used with these components are the dipper pitch braces, dipper padlock, sheave, dipper teeth and side plates, dipper hinge pin, dipper hoist sheave, boom foot pins, wire rope for the A-frame suspension boom hoist, and dipper pull rope.

The backhoe is used to dig trenches, footings, and basements. It is excellent for this type work because it digs straight, vertical sidewalls; cuts a level floor; trims corners neatly and squarely; works from the top on dry safe ground; and reduces hand trim to a minimum.

The backhoe disposes of material either by loading into hauling units or by dumping on a spoil bank. Its dumping range is not as far as that of the dragline unit because of the fixed dimensions of the boom stick.

The following factors have a major effect upon the capacity of a backhoe: width of excavation desired, depth to be worked, type of material to be handled, and method of disposal of material. All of these factors affect the cycle of operation which directly affects the output capacity of the backhoe. Therefore, for planning purposes or as a guide, the selection of the right size dipper bucket for the backhoe is a critical element of backhoe production. The effect of this selection can best be described by the following



29.67

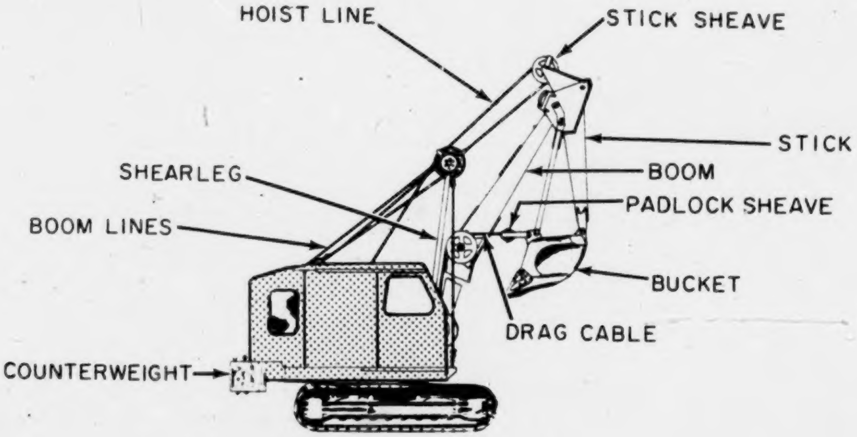
Figure 11-15. — Crane with dragline attachment.

examples: a typical backhoe equipped with a 1/2-yard bucket will only have a rated digging depth of about 17 feet; using a 3/4-yard bucket will give a 20-foot rated digging depth; and a machine equipped with a 1-1/2-yard bucket will have a rated digging depth of 26 feet.

It should be noted that the cycle of operation of the backhoe is somewhat less than that of the clamshell and closer to that of the shovel—allow 20 to 35 seconds per pass.

POWER SHOVEL

The shovel attachment (fig. 11-17) is composed of four major components: a heavy-duty box type boom, saddle block, dipper-stick, and dipper.



29.69

Figure 11-16. — Crane with backhoe attachment.

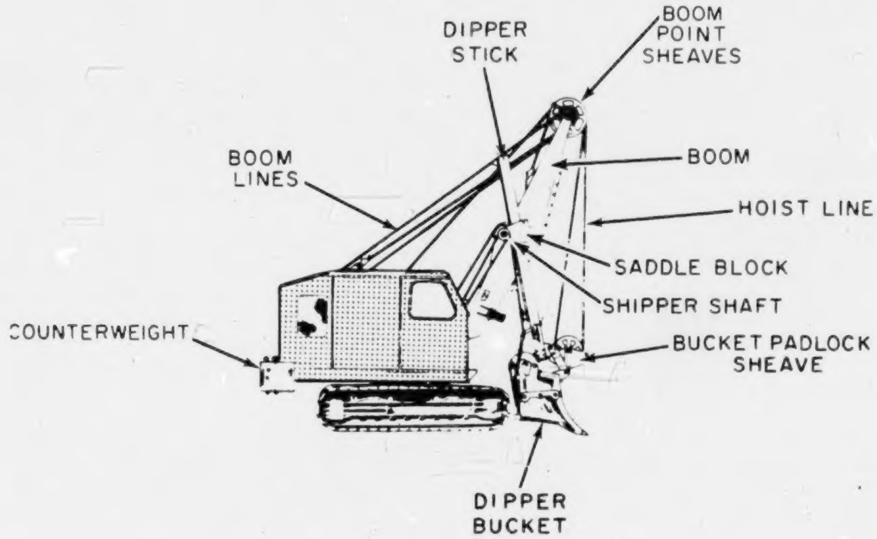


Figure 11-17. — Crane with shovel attachment.

Used with these components are wire ropes for boom suspension, for dipper hoist, and for crowd and retract action. Some shovels have a roller chain and wire rope combination crowd and retract, or all chain crowd and retract.

The shovel will dig at, above, and below ground level. It is capable of digging and loading material that is loose to hard, such as bank gravel. The shovel can load trucks that are spotted on the bank above ground level of the machine. When digging below ground level, the shovel is limited to depth by the length of the dipper-stick. When the shovel is used to excavate below ground level, the machine must straddle the trench as it is being dug. Caution must be exercised when excavating a ditch in soft soil, to ensure that the excavation does not cave in and the machine tip over.

The shovel is the most effective attachment to use for the excavation of hard, compact material at the face of an embankment and for loading the material onto haul units.

The shovel can be used for stripping of overburden with the material being dumped onto spoil banks. On hillside or mountainside road construction, material can be dumped over the embankment. In sand or gravel pits, material can be dumped onto a belt conveyor or grizzly.

The nature of the excavation requires a sufficient depth of cut for maximum effect. The height of the embankment should not exceed the height of the boom tip. With the top of the embankment higher than the boom tip, the dipper will undercut because it cannot reach high enough to cut the material down due to the shipper shaft height. This situation can cause the embankment to break off in large chunks which can severely damage the machine.

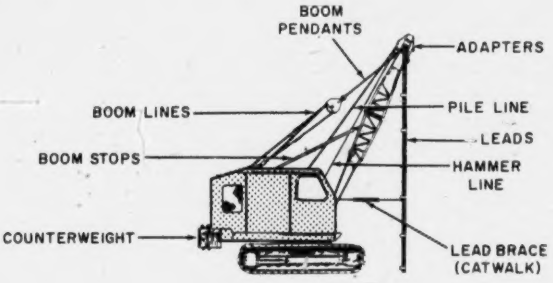
In hard digging, with the shovel boom set at an angle of approximately 50 degrees, the radius between the center pin and the dipper is shorter. This makes the counterweight more effective in preventing tipping of the machine.

Excavating too far beyond the boom point is never practical because the power available diminishes rapidly as the dipper-stick is extended beyond the imaginary line plumbed from the boom point to the ground.

PILEDRIVER

The piledriver is used to drive various types of wood, steel, and concrete piling for foundations, bridge bents, piers, and wharves.

The piledriver shown in figure 11-18 consists of a crane boom, adapter plates, leads, catwalk (lead braces), hammer, and necessary wire ropes.



115.494
Figure 11-18.—Crane with piledriver attachment.

The adapter plates are bolted to the top section of the leads and fastened to the boom tip shaft. The leads are fastened to the foot of the boom by the telescopic braces that make up the catwalk. The hammer may be air-, steam-, diesel-, or gravity-operated.

To help ensure maximum production, the piledriver should be placed so that a minimum amount of time is lost due to moving. This placement is generally parallel to the long axis of the pile group. The piles should be close enough to the site that the operator need only swing to pick up the next pile. The piledriver should be placed on level, stable soil while driving. When driving from a barge, the barge should be anchored tightly and remain stationary. Piles are preferably driven off the end of the barge. Light continuous blows by the pilehammer are perferable to heavy frequent blows, which cause more pile failure.

OPERATION OF CRANES AND ATTACHMENTS

Information on prestart checks, during operation checks, operating procedures, and securing methods typical of cranes and attachments used by the Navy is given in the following sections. Bear in mind, however, that this chapter does not attempt to tell you all you need to know about the operation of cranes and attachments. The sole source of complete and authentic information on crane and attachment operations is the operator's manual provided by the manufacturer of the crane or attachment concerned.

PRESTART CHECKS

Prestart checks and operator services made on cranes and attachments are similar to those described for equipment in previous chapters of this manual. However, the location of items to be checked differs from one type of crane and attachment to another.

Make sure the hydraulic boom is cradled and all hydraulic control valves are in the hold position. Remove the hydraulic tank screen and breather from the hydraulic reservoir located on the left side of the operator's compartment. Check the level of the hydraulic oil in the reservoir. When necessary, add the specified type of hydraulic oil to bring the level within 6 inches below the top of the tank.

STARTING CHECKS

After starting the engine, and before putting a crane into operation, a few checks are necessary. These checks are basically the same which have been covered in previous chapters. Only additional checks peculiar to the hydraulic type of crane will be given below.

The hydraulic system pressure gage will show the safe and log ranges of the hydraulic system pressure. When the pressure reaches approximately 1550 psi, the system has attained safe operating pressure. As the controls are operated, the constant use of hydraulic oil will eventually cause the accumulator pressure to drop to the low end of the operating range, at approximately 1400 psi.

Check the rear steering indicator light. When the RED light is on, it indicates that the rear wheels are not straight ahead. When the RED light is off, it indicates the rear wheels are straight.

DURING OPERATION CHECKS

Malfunctions may be present even though all indicators on the crane register within the specified range during operation. There are various symptoms by which common types of malfunctions can be identified. These symptoms are the same as described in previous portions of this manual for automotive vehicles and tractors and attachments; therefore, the symptoms need not be repeated here.

OPERATING CRAWLER-MOUNTED CRANE

A variety of front-end attachments are used on crawler-mounted cranes because no one type of boom or mounting is suitable for every job. Therefore, the safe and efficient use of a crawler-mounted crane requires skill and alertness on the part of the operator.

Before operating the crawler-mounted crane, you should first become familiar with its different indicators and controls. Figure 11-19 shows the indicators and controls of the P & H model 640 crawler-mounted crane. The purpose of the various indicators and controls is explained below; the numbers in parentheses correspond to those used in figure 11-19 to indicate the location of indicators and controls.

The ENGINE STARTING SWITCH (1) is an automotive type switch which closes the circuit that energizes the engine starting motor.

The GLOW PLUG SWITCH (2) is provided to turn on the engine heating device, called a glow plug, for cold weather starting. A light will indicate when the glow plug is energized.

The PRIMING PUMP PRESSURE GAGE (3) indicates fuel pressure under starting conditions only.

The ENGINE HOUR METER (4) records the actual hours of engine operation. It eliminates guesswork when determining proper lubrication and maintenance periods.

Before starting in cold weather, the ENGINE PRIMING PUMP LEVER (5) is used to prime the engine.

To engage or disengage the locking device within the cooling fins of the crane's REAR drum, the MANUAL LOCK LEVER (6) is used.

To engage or disengage the locking device within the cooling fins of the crane's FRONT drum, the MANUAL LOCK LEVER (7) is used.

By mechanically applying the SWING BRAKE LOCK LEVER (8) in the forward position, the swing brake is applied, locking the crane's upper revolving unit over the front of the crawler assembly.

The HYDRAULIC SYSTEM PRESSURE GAGE (9) shows the safe and low ranges of the hydraulic system pressure.

The CRAWLER STEERING LEVER (10) controls the crane steering operations. Push the control lever away from you and the machine turns left; pull the control lever towards you and the machine turns right; release the lever and it returns to the "hold" position.

To engage the REAR (HOIST) DRUM BRAKE LOCK LEVER (11), pull it towards you to retain the pressure applied to the rear drum brake. To release the pressure, first apply a small amount of pressure to the rear drum brake pedal. Then, gradually push the lever away from you to release the pressure on the brake.

To engage the FRONT (DIGGING) DRUM BRAKE LOCK LEVER (12), pull it towards you to retain pressure applied to the front drum brake. To release the pressure, first apply a small amount of pressure to the front drum brake pedal. Then, gradually push the lever away from you to release the pressure on the brake.

The engine fuel tank gage, engine oil pressure gage, engine temperature gage, and the ammeter gage are contained in the GAGE GROUP (13).

The TRANSMISSION SHIFT LEVER (14) is used to select and position the crane transmission for slow line speed, normal service, or light crane application or service.

The ENGINE CLUTCH LEVER (15) is used to engage or disengage the engine clutch. By pushing the lever forward, the engine clutch is engaged. By pulling back on the lever, the engine clutch is disengaged.

When the SWING LEVER (16) is pushed forward, the upper revolving unit swings to the left. When you pull back on the lever, the upper revolving unit swings to the right.

By depressing the FRONT DRUM BRAKE PEDAL (17), the front drum brake is applied.

When the FRONT DRUM LEVER (18) is pulled toward you, the front drum rotates in the direction that will wrap wire rope on the drum. When you push the lever forward, the wire rope will pay off the drum.

By pulling the REAR DRUM LEVER (19) toward you, the rear drum rotates in the direction that will wrap wire rope on the drum. When you push the lever forward, the wire rope will pay off the drum.

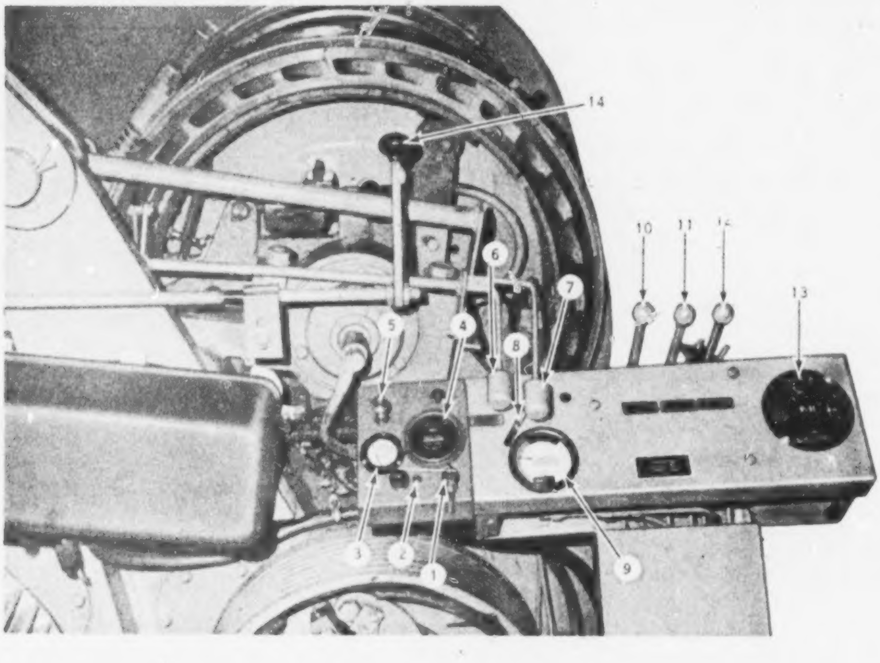


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Figure 11-19.—Indicators and controls, P & H model 640, crawler crane.

By depressing the REAR DRUM BRAKE PEDAL (20), the rear drum brake is applied.

When the BOOM HOIST BRAKE AND CLUTCH LEVER (21) is pulled toward you, the boom will raise. When you push the lever forward, the boom will lower. It may be necessary to raise the boom slightly before it can be lowered in order to disengage the boom hoist pawl.

When you pull the SWING BRAKE LEVER (22), hydraulic pressure is supplied, allowing release of the swing brake. However, you must pull the SWING BRAKE LOCK LEVER (8) towards you to retain this pressure as the swing brake is released.

The ENGINE THROTTLE CONTROL (23) is used to control engine speed and to shut down the engine by cutting off the fuel.

By pushing forward on the PROPEL CONTROL LEVER (24) the propel clutch is engaged and the machine is propelled forward. When you pull backwards on the lever, the machine is propelled to the rear.

> NOTE: All propel and steering directions mentioned above are based on the assumption that you have positioned the upper revolving unit over the front of the crawler assembly, traveling forward.

Starting The Engine

In starting the P & H model 640 crawler-mounted crane engine under normal conditions, follow the step-by-step procedure given below.

(1) Disengage the engine clutch and place the transmission in neutral.

(2) Place the ignition switch in the START position to start the engine. Do not hold the starting motor ON for more than 30 seconds at a time. If the engine does not start in this period of time, wait until the starting motor stops before trying again.

When the engine starts, allow it to run at part throttle, no load, for about 5 minutes to warm up. Observe the gages on the instrument panel for proper readings.

Steps For Operating

To place the P & H model 640 crawler-mounted crane in motion after the engine has started, follow this procedure:

(1) Set the crane engine throttle at load speed.

(2) Check all controls and brakes for proper operating position.

(3) Engage the engine clutch lever.

(4) Position the transmission shift lever in the desired speed of operation.

(5) Engage the propel control lever in the desired position and move the crane to the operating area.

Stopping The Crawler-Mounted Crane

To bring the crane to a stop, proceed as follows:

(1) Disengage the propel control lever.

(2) Lower the crane load or attachment to the ground.

(3) Set all brakes and safety pawls.

(4) Position the transmission shift lever to neutral.

(5) Disengage the engine clutch.

Stopping The Engine

To stop the crane engine, follow this procedure:

(1) With no load on the engine, decrease engine speed and allow the engine to run at half speed or less for a few minutes before closing the throttle and stopping the engine. This will allow the engine to cool down and permit gradual and uniform cooling.

(2) Place the engine throttle control in the fuel shut-off position.

(3) Turn the key switch counterclockwise to the OFF position.

Hookblock Operations

In operating a crane equipped with basic attachments, start all jobs, when possible, from relatively level ground. If necessary, level and area large enough to provide sufficient working space for the crane. When using the crane with the HOOKBLOCK attachment (fig. 11-9), follow the procedure below for efficient operation.

1. Be sure the footing is adequate.
2. Where repetitive lifting is involved, position the crane for the shortest possible swing.
3. Level the crane to avoid swinging "uphill" or "downhill." Level footing requires less power and is faster and safer.

4. Use taglines to avoid excessive swinging of bulky loads.

5. Use adequate lengths of hoist line to assure full travel of the hookblock to the lowest point required.

6. Organize the work for minimum travel time. All lifts required in one area should be completed before moving to a new location.

7. Use power down equipment where precise load handling is required.

8. Do not use excessive counterweight or tiedown devices to increase stability. Their use will cause additional stress and equipment failures.

The crane operating cycle includes the following steps: setting the boom angle (boom hoist operations), lifting the load, swinging, spotting, and lowering the load.

To set the boom angle, position the crane boom at the proper angle for the load and working conditions. Find the correct angle from the load rating data plate mounted in the cab. On some cranes, the boom is raised by engaging a boom hoist clutch. Lower the boom by first releasing the boom gear locks and then moving the boom lever in the opposite direction. Lowering is usually controlled by a boom brake. However, the booms on most makes of cranes used by the SEABEES are lowered under power. In this case, the boom is lowered through the gears.

To lift the load, attach the crane hook securely to the load. Engage the hoist clutch and release the hoist drum brake to take up on the hoist cable. Hoist the load to the desired height. To stop hoisting, apply the hoist drum brake and disengage the hoist drum clutch.

To swing the load, engage the swing clutch for a right or left swing. This should be done slowly so that the swing motion will start and stop smoothly. When the swing has been completed, engage the opposite swing clutch lightly to stop the motion.

Spotting and lowering the load requires accurate control of the hoist and swing movements in order to locate the load at the exact spot without hunting or overshooting. The load can be lowered by partially releasing the hoist brake or by power.

Clamshell Operations

When using the crane with the CLAMSHELL attachment (fig. 11-12), the following procedure applies:

1. Level ground is preferred for positioning the unit.

2. Position the unit so that the clamming or digging operation is the same radius as the dumping operation; this is to avoid excessive wear on the boom mechanism and the wasting of production time by moving the boom.

3. Select the correct bucket size for the machine.

4. When lowering the clamshell bucket, if too much pressure is applied to the closing line brake, the bucket will close and excess line will unwind off the holding drum. To avoid this, release the holding line and closing line brakes to lower the open clamshell into the material for the initial bite. Engage the closing line clutch and release the brake. Control the digging depth by using the holding line clutch and brake.

5. During hoisting, if the hoist line gets ahead of the closing line—the bucket will open and spill the material. (This could be caused by too much wire rope on the hoist drum). In this event, when the bucket is at the desired height, apply both holding and closing line brakes and disengage both clutches.

The clamshell operating cycle includes the following four steps: filling (closing) the bucket, raising the loaded bucket, swinging and dumping. The boom position is set before beginning the digging operations.

Filling (closing) the bucket is accomplished by lowering the open clamshell until it is about a foot above the material to be worked.

As soon as the bucket is almost closed and loaded, keep the closing line clutch engaged and engage the holding line clutch so that both cables are taken up at the same time.

When the clamshell is raised enough to clear all obstacles, start the swing by engaging one of the swing clutches. Hoisting the bucket can be continued as it is swung to the dumping site. The spring-loaded tagline will retard the twisting motion of the bucket if the swing is done smoothly.

Dumping or unloading the clamshell is accomplished by keeping the holding line brake applied while the closing line brake is released. Apply the closing line brake quickly after the load is dumped to prevent the closing line from unwinding more wire than is needed to drop the material. After the bucket is emptied, swing the open clamshell back to the digging site. Then lower the open bucket and repeat the cycle.

Dragline Operations

When using the crane with a DRAGLINE attachment (fig. 11-15), follow the operational procedures below.

1. The dragline bucket teeth should be kept sharp and built up to proper size.
2. The dump rope should be kept short so the load can be picked up well out from the machine.
3. The working area should be excavated in layers, not in trenches, and kept sloped upward toward the machine.
4. The bucket should not be dragged in so close to the machine that it will build up piles and ridges of material in front of the machine.
5. The bucket should never be guided by swinging the machinery deck frame while digging. This puts side stress on the boom which can cause failure. The swing should not be started until the bucket has been raised clear of the ground.
6. A pair of drag chains are attached to the front of the bucket through brackets by which the pull point may be moved up or down. The upper position is used for deep or hard digging as it pulls the teeth into a steeper angle.
7. The dragline cable can be end-for-end to prolong cable life, reduce early cable replacement, and keep cable replacement costs to a minimum.

The dragline operating steps can be worked in a smooth, even order. These steps include: filling the bucket, lifting the bucket, swinging the load, and dumping the load. The boom angle is usually set before beginning the digging operation.

In lowering the dragline bucket into the area to be worked, release the drag brake to tip the cutting edge down and then release the hoist brake. It is not necessary to drop the bucket to force the teeth into the material. The bucket is filled as it is dragged toward the machine by engaging the drag drum clutch and releasing the drag brake. The cutting depth is controlled by slacking off on the hoist brake.

When lifting the dragline bucket, raise the load by engaging the hoist clutch and releasing the hoist brake. At the same time, slip the drag brake to allow the bucket to carry toward the boom point. To hold the bucket at the desired height, apply both footbrakes and disengage the hoist clutch.

When swinging as the bucket is raised, engage the swing clutch to swing toward the dump site. The hoisting and swinging operations can be done at the same time.

For dumping the load when approaching the dump site, release the drag brake to unreel enough cable for the bucket to dump completely. Apply the drag brake to keep from unwinding excess cable. Swing the boom back to the digging area and repeat the steps of the operating cycle.

Backhoe Operations

When using the crane with the BACKHOE attachment (fig. 11-16), here is the operational procedure to follow.

1. The backhoe dipper teeth should be kept sharp and built up to proper size.
2. The most convenient position for a truck to be loaded by a backhoe is as close to the machine as possible in order to reduce spillage. Back the haul unit toward the backhoe to allow dumping in the full length of the truck body. The danger in this position is the possibility of the drag rope breaking which may permit the dipper to swing outward, taking the truck cab with it. For this reason, trucks are often loaded from the side. The dipper should be guided by swinging the machinery deck frame only before the digging begins. Never swing the machinery deck frame during the time of digging, otherwise undue side stress on the boom results.

The backhoe operating cycle, which is basically the same as the dragline, includes the following steps: filling the bucket during its digging motion, dragging, hoisting, swinging, dumping, and return to the digging position. The backhoe main boom angle, being flexible, allows the operator to change the digging depth and the hoisting height.

Filling the backhoe bucket requires coordination in hoisting and dragging (pulling). The bucket can be moved out horizontally from any raised position by releasing or slipping the drag brake so that the bucket swings out, engaging the hoist clutch enough to prevent hitting the ground. When it is almost fully extended or is at the desired distance, the drag clutch is applied and the hoist drum released. The boom, stick, and bucket will fall together, striking the teeth on the ground with a pickaxe effect. Engage the drag clutch, release the hoist, and the bucket will move toward the basic crane. The drag clutch is partially or intermittently engaged. As soon as the bucket is filled, the hoist clutch is engaged, the drag clutch is released, and the drag brake applied with the hoist continuing.

The swing clutch is engaged to swing to the left or right. All models require the use of the opposite swing clutch to slow the swing to a stop. During the swinging of the bucket, hoisting continues until you reach the dumping position, and finish dumpping.

When the bucket reaches the dumping position, the drag brake is released and the bucket swings outward, dumping the material. As it reaches its outward swing, release the hoist clutch and apply the hoist brake. Start swinging the empty bucket back toward the cut being worked. Lower the bucket by releasing the hoist brake to allow the boom and stick to lower to the digging position and start the cycle once again.

Shovel Operations

When using the crane with the SHOVEL attachment (fig. 11-17) for shovel operation, the following procedure applies.

1. The shovel should be positioned on ground that is as level as possible. When used in areas where material is soft, the shovel should be supported on construction mats. Only material that is broken up small enough to pass through the dipper should be handled.
2. At the start of digging, the dipper should be at crawler (or wheel) level and two or three feet in front of the crawlers (or wheels).
3. The shovel should travel on ground that is free of holes and large boulders so that the tracks will have bearing for their full length. A rocking shovel is difficult to operate and may cause damage to the track frames.
4. For best results, the shovel should be kept moved up to the working face. After each move up, the proper digging sequence is to start at the center of the face and make alternate passes on each side of the center until all of the face within reach is cut back evenly. The dipper should be filled by a straight forward pass against a working face at optimum bank height. When the excavation is deep, the working face is terraced.
5. When excavating hard material with the shovel, lifts that raise the tracks off the ground should be avoided because of possible damage to the track frames.

The shovel operating cycle includes the following steps: filling the dipper, swinging, dumping and return to the digging position. The shovel boom angle is usually set before beginning shovel operation. The boom angle for shovel operation is approximately 45 degrees.

Filling the dipper requires the coordination of two movements: hoisting and crowding (shoveling). Hoisting the bucket is done first by engaging the bucket hoist clutch and releasing the bucket hoist brake. As the dipper begins its lift, the digging depth is controlled by engaging the crowd clutch and releasing the crowd brake; this allows the dipper to crowd into the bank. As soon as the dipper is filled, both brakes are applied and the hoist and crowd clutches are released.

Before swinging the extended dipper, make sure that it will clear the bank by rehauling the dipper, if necessary. After this is done, the swing clutch is engaged to swing either left or right. All models require the use of the opposite swing clutch to slow the swing to a stop. As the shovel is swinging, adjust the length of the dipper-stick by crowding or retracting so that the dipper door will be directly over the dumping point when the swing is completed.

When the dipper is over the dumping point, raise or lower the dipper, if necessary, to the proper height for dumping. Then engage the dipper trip clutch to open the dipper door. Hoist the dipper enough to allow the open door to clear all obstructions.

Start swinging the empty dipper back toward the cut being worked. Retract the dipper as necessary to clear the bank. Lower the dipper by releasing the hoist brake to allow the dipper to swing back under the boom. Also, release the crowd brake to drop the dipper to the ground. Do not let the dipper strike the boom or the carrier.

Piledriver Operations

The crane with a PILEDRIVER attachment is shown in figure 11-18. The type of piledriving hammer used in piledriving operations may be a drophammer, a diesel-driven hammer, or a pneumatic/steam hammer. Assume for the purposes of this discussion that you are using the drophammer. The piledriving operational procedure to follow when using this type equipment is given below.

1. The piledriver should be placed on level, stable soil while driving.
2. The piledriver should be placed so that only a minimum amount of time will be lost in moving.
3. The piledriver placement is generally parallel to the long axis of the pile group.
4. The piles should be close enough to the site that you need only to swing the crane to pick up the next pile.

The piledriving operating cycle includes the following steps: positioning the hammer and pile cap, raising the pile from the horizontal to the vertical, lowering the hammer and cap onto the top of the pile, removing the pile hoist line hitch from the pile and the cap sling from the hammer, and driving the pile. The piledriving lead's position is set before beginning the driving operation.

Hoist the hammer and cap by engaging the rear drum hoist clutch lever (hammer and cap line) and releasing the rear drum hoist brake. As the hammer and cap begin to lift, the height of the lift is controlled by applying the brake and releasing the hoist clutch.

Hoist the pile into the desired position by engaging the front drum hoist clutch lever (pile line) and releasing the front drum hoist brake. As the pile reaches the desired position, apply the brake and release the hoist clutch.

Lower the hammer and cap by releasing the hammer line brake until the hammer and cap are positioned over the pile.

Remove the pile hoist line hitch from the pile and the cap sling from the hammer before driving.

Engage the rear drum hoist clutch lever and release the rear drum hoist brake, raising the hammer about 10 feet. Control the lift by applying the brake and releasing the hoist clutch.

Lower the hammer by releasing the hoist brake to allow the hammer to drive the pile, and start the cycle once again, remembering to keep a steady rate of speed on the hammer while raising and lowering it.

OPERATING TRUCK-MOUNTED CRANES

Before operating a truck-mounted crane, you should first become familiar with its different indicators and controls. Figure 11-20 shows the indicators and controls of the upper revolving unit of the P & H model 325TC truck-mounted crane. The purpose of various indicators and controls is described below; the numbers in parentheses correspond to those used in figure 11-20 to indicate the location of individual indicators and controls.

By pushing forward on the SWING CLUTCH LEVER (1), the upper revolving unit swings to the left. When you pull back on the lever, the upper revolving unit swings to the right.

When the LEFT MAIN DRUM CLUTCH LEVER (2) is pulled towards you, the left main drum rotates in the direction that will wrap wire rope on the drum. When you push the lever forward, the wire rope will pay off the drum.

By pulling the RIGHT MAIN DRUM CLUTCH LEVER (3) towards you, the right main drum rotates in the direction that will wrap wire rope on the drum. When you push the lever forward, the wire rope will pay off the drum.

When the BOOM HOIST CLUTCH LEVER (4) is pulled towards you, the boom raises. When you push the lever forward, the boom hoist brake will release and the boom will lower under power through the planetary gear system. Returning the lever to the neutral position will set this boom hoist brake and hold the boom in the new position. With the boom hoist drum stopped, pull the BOOM HOIST DRUM PAWL CONTROL (17) to engage the safety pawl in the drum ratchet. The pawl should be engaged at all times except when lowering the boom.

The ENGINE HAND THROTTLE (5) is used to control engine speed and to shut down the engine by cutting off the fuel.

The LEFT (6) and RIGHT (7) MAIN DRUM BRAKE PEDALS are pushed down to apply the left and right main drum brakes. The ratchet-type foot pedal lock is engaged by pressing down on the toe of the pedal before releasing the brake. To disengage the brake lock, press down on the pedal and tip the pedal back, using the heel of the pedal. When the optional planetary lowering is not supplied for the left and right main drums, loads on the drum lines are lowered by gravity under control of the brake.

The TRANSMISSION SHIFT LEVER (8) is used to select and position the upper revolving unit engine transmission for slow line speed for fine line control, normal service for all types of operation, light service where speedy operation is desired, or light service for maximum line speed.

When the SWING BRAKE LEVER (9) is pulled towards you the swing brake is applied. When the pushbutton on the lever handle is depressed and the lever is pushed forward, the swing

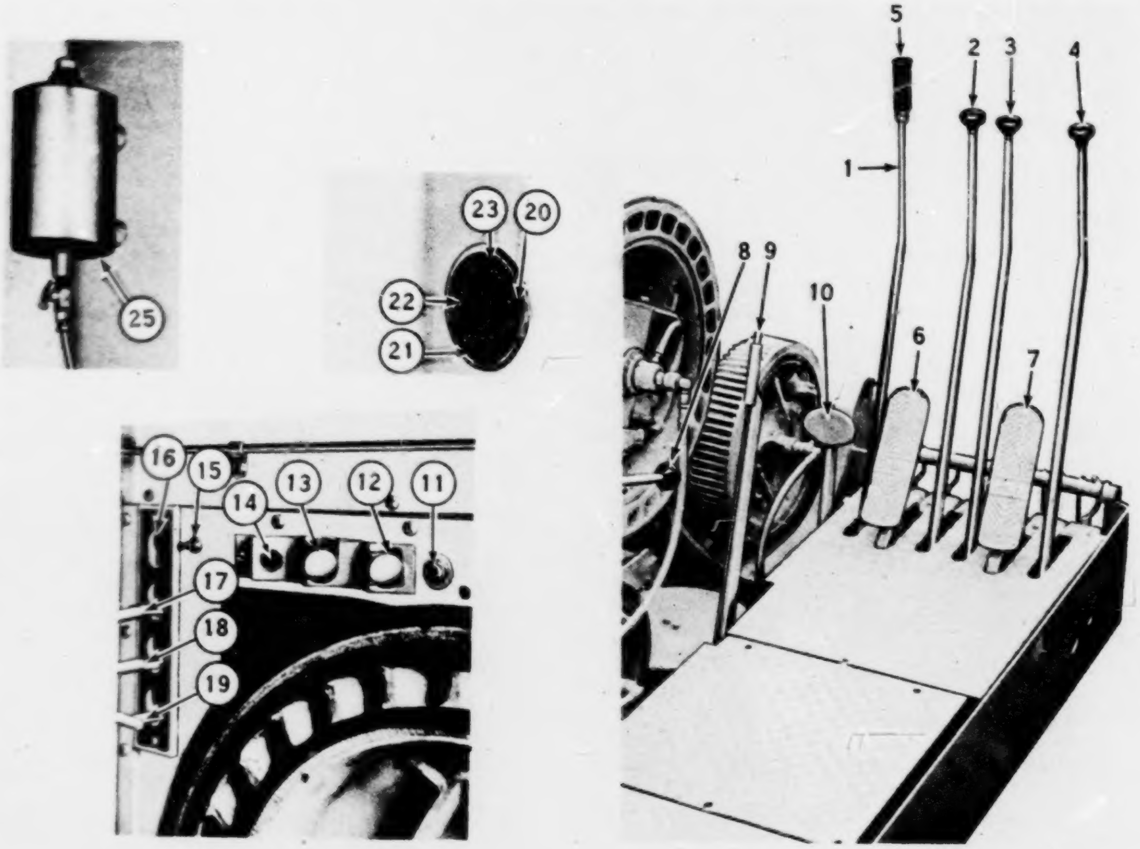


Figure 11-20.—Indicators and controls, P & H model 325TC, truck-mounted crane upper revolving superstructure. 115.496

brake is released, allowing you to swing the upper revolving unit in the desired direction.

The ENGINE CLUTCH PEDAL (10) is depressed to disengage the engine clutch before shifting the TRANSMISSION SHIFT LEVER (8) into the desired operating speed. When shifting is completed, release the clutch pedal.

The STOP KNOB (13), when pushed in, stops the gasoline engine. This knob is used as an emergency stop with diesel engines.

The IGNITION SWITCH (15) is pulled out to turn on the engine ignition.

The RIGHT (18) and LEFT (19) MAIN DRUM PAWL CONTROL LEVERS are pulled out to engage the safety pawl in the right and left drum ratches when the right and left main drums are stopped. This pawl should always be engaged when suspending a load aloft.

The ENGINE OIL PRESSURE GAGE (20) registers the pressure at which lubricating oil is circulating through the engine.

The ENGINE WATER TEMPERATURE GAGE (21) registers the temperature of the coolant circulating through the engine.

The ENGINE FUEL GAGE (22) indicates the level of fuel within the fuel tank.

The ENGINE AMMETER (23) indicates the rate at which the battery is being charged or discharged.

The HYDRAULIC OIL RESERVOIR (25) contains the proper amount of hydraulic brake fluid to supply the individual compensators (or master cylinders) for each clutch and brake operated by the various controls and pedals.

Starting The Upper Revolving Unit Engine

In starting the P & H model 325TC upper revolving unit engine under normal conditions, follow the step-by-step procedure given below.

(1) Disengage the engine clutch, place the transmission in neutral, and open the throttle slightly.

(2) Place the ignition switch in the START position to start the engine. Do not hold the starting motor ON for more than 30 seconds at a time. If the engine does not start in this period of time, release the starting switch and wait until the starting motor stops before trying again.

After the engine starts, allow it to run idle, at part throttle, for about 5 minutes to warm up. Observe the gages on the instrument panel for proper readings.

Steps For Operating

Observe the following operating steps for placing the P & H model 325TC upper revolving unit in motion after the engine has been started:

(1) Set the engine hand throttle control at load speed.

(2) Check all controls and brakes for proper operating position.

(3) Disengage the engine foot clutch pedal.

(4) Position the engine transmission shift lever in the desired speed of operation.

(5) Release the engine foot clutch pedal.

(6) Depress the pushbutton on the swing brake lever and place the lever in the forward position; this allows the crane to be swung in either direction.

(7) To perform the various functions desired, actuate the necessary control levers and drum brake pedals.

Stopping The Upper Revolving Unit

To bring the upper revolving unit to a stop, proceed as follows:

(1) Swing the upper revolving unit in proper position over the truck carrier.

(2) Engage the swing brake lever.

(3) Position the load or attachment for travel.

(4) Set all control levers and drum brakes.

(5) Disengage the engine foot clutch pedal.

(6) Place the transmission shift lever in neutral.

(7) Release the engine foot clutch pedal.

Stopping The Upper Revolving Unit Engine

To stop the upper revolving unit engine, the following steps must be taken:

(1) With no load on the engine, decrease engine speed and let the engine run at half speed or less for a few minutes before closing the throttle and stopping the engine. This will allow the engine to cool down and permit gradual and uniform cooling of engine parts.

(2) Place the engine throttle in the FUEL SHUT OFF position.

(3) Turn the key switch counterclockwise to the OFF position.

OPERATION OF TRUCK CARRIER

Before operating the truck carrier of the truck-mounted crane, you should first become familiar with its different indicators and controls. Figure 11-21 shows the indicators and controls of the truck carrier for the P & H model 325TC truck-mounted crane. The purpose of various indicators and controls is described below; the numbers in parentheses correspond to those used in figure 11-21 to indicate the location of individual indicators and controls.

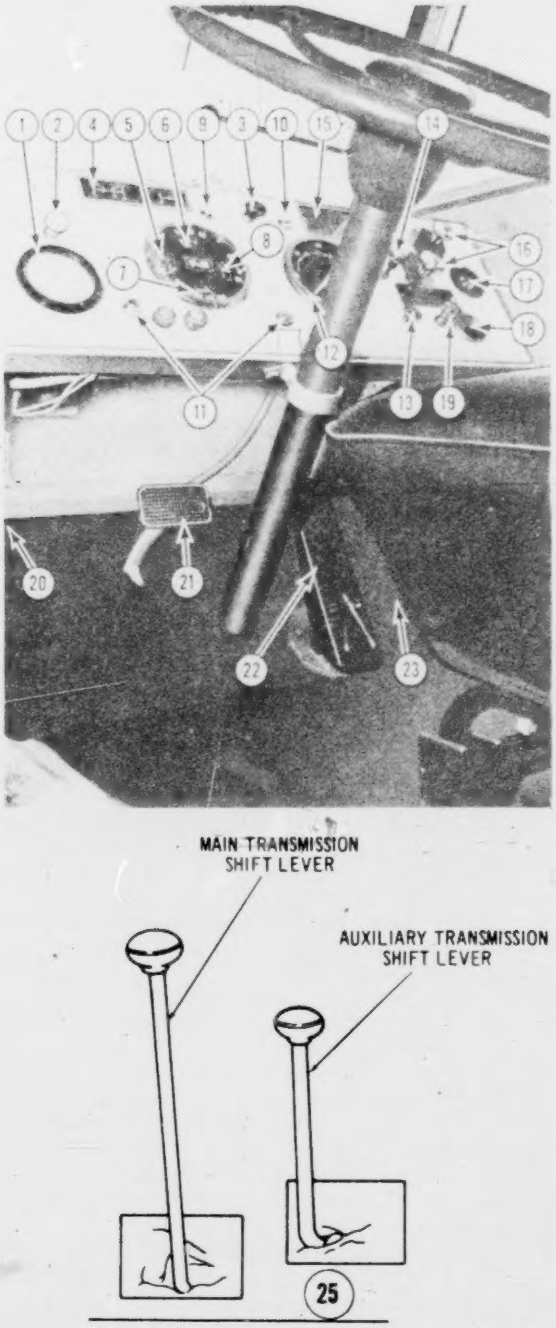
When shifting the main transmission from one speed to another when moving the truck crane, the ENGINE TACHOMETER (1) allows the operator to read and maintain proper engine rpm.

The MAXIBRAKE CONTROL KNOB and EMERGENCY RELEASE VALVE (16) are used in the application and release of the truck carrier parking brakes. By depressing the control knob the truck carrier brakes are applied. When you depress the emergency release valve, the truck carrier parking brakes are released.

Low brake system air pressure is indicated by the LOW AIR PRESSURE GAGE (17).

The AIR PRESSURE GAGE (18) registers the air pressure within the airtank reservoirs (60 lbs pressure is required).

Before shifting the TRANSMISSION SHIFT LEVER and AUXILIARY TRANSMISSION SHIFT LEVER (25) into the desired operating speed,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MAIN TRANSMISSION SHIFT LEVER
AUXILIARY TRANSMISSION SHIFT LEVER
25

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Figure 11-21.—Indicators and controls, P & H model 325TC, truck-mounted crane truck carrier.

the CLUTCH PEDAL (21) is depressed to disengage the truck carrier engine clutch. When shifting is completed, release the clutch pedal.

The TREADLE BRAKE PEDAL (22) provides you with a graduated means of applying and releasing the truck carrier brakes.

Starting The Truck Carrier Engine

In starting the P & H model 325TC truck carrier engine under normal conditions, follow this step-by-step procedure:

(1) Disengage the engine clutch and place the transmission in neutral.

(2) Place the engine ignition switch in the ON position and depress the starter button. After the engine starts, allow it to run idle, at part throttle, for about 5 minutes to warm up. Observe the gages on the instrument panel for proper readings.

Steps For Operating

Observe the following steps for placing the truck carrier in motion after the carrier engine has been started:

(1) Disengage the engine clutch pedal.

(2) Position the transmission shift lever and auxiliary transmission shift lever in the desired speed range.

(3) Release the parking brake.

(4) Engage the engine clutch by releasing the clutch pedal and depress the foot accelerator pedal, thus increasing the speed of the engine.

(5) Shift the main transmission lever into the proper speed ranges as the crane moves to the operating area.

Stopping The Truck Carrier of The Truck-Mounted Crane

To bring the truck crane to a stop, proceed as follows:

(1) Decrease the engine speed by releasing the foot pressure on the accelerator.

(2) Apply pressure to the treadle brake pedal.

(3) Disengage the engine clutch.

(4) Shift the transmission shift lever and the auxiliary transmission shift lever to neutral.

(5) Engage the truck crane parking brake.

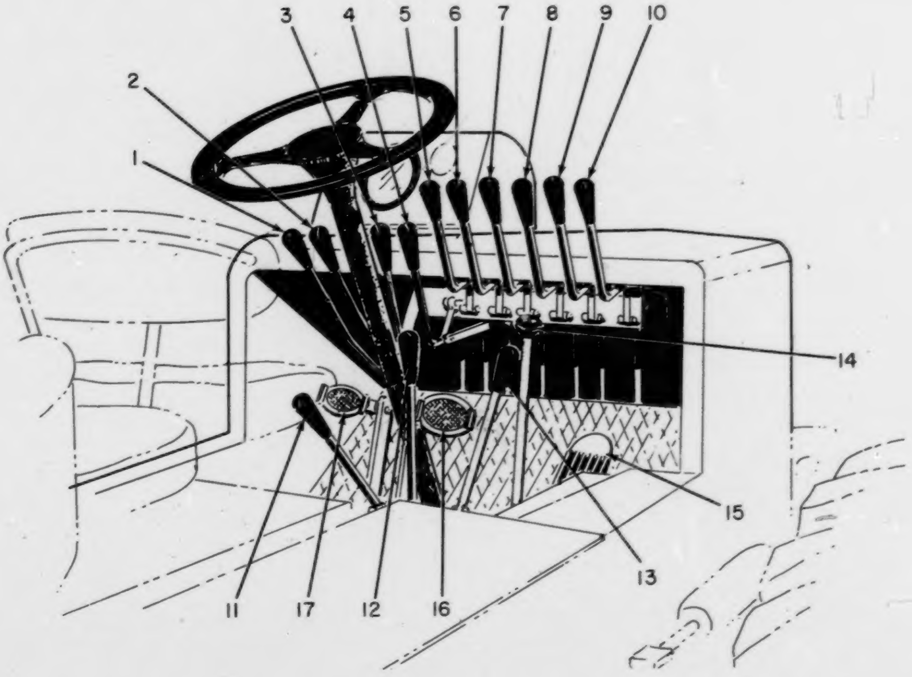

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Figure 11-22. — Controls, Galion model 125, wheel-mounted crane.

Stopping the Truck Carrier Engine

To stop the truck carrier engine, take the following steps:

(1) With no load on the engine, allow it to idle before turning the ignition switch to the OFF position. This allows the engine to cool down and permits gradual and uniform cooling of engine parts.

(2) Turn the ignition switch to the OFF position.

Operation Techniques

Operating techniques which were described in previous sections of this chapter on the operation of the crawler-mounted crane also apply basically to the truck-mounted crane. Therefore, these operating techniques need not be repeated here.

OPERATING WHEEL-MOUNTED CRANE

In previous sections, we discussed the crawler-mounted crane and the truck-mounted crane. Now let's turn our attention to the wheel-mounted crane. The following information will acquaint you with the instruments, controls, and operational capabilities of the Galion model 125 wheel-mounted crane. The purpose of this crane's various controls is explained below; the numbers in parentheses correspond to those used in figure 11-22 to indicate the location of the controls.

When the LEFT REAR (1), LEFT FRONT (2), RIGHT FRONT (3), and RIGHT REAR (4) OUTRIGGER CONTROL LEVERS are pushed forward, this will cause the left rear, left front, right front, and right rear outriggers to be lowered; when these levers are pulled backwards, the left rear, left front, right front, and right rear outriggers are raised.

By pushing forward on the REAR STEERING CONTROL LEVER (5), the rear wheels on the crane will turn left; when you pull this lever backwards, the rear wheels will turn right.

By pushing forward on the BOOM ROTATION CONTROL LEVER (6), the boom will rotate counterclockwise. Pull the lever backwards and the boom will rotate clockwise.

When the LOW LINE SPEED CONTROL LEVER (7) is pushed forward, the hook will lower; when this lever is pulled backwards, the hook will raise.

When the INTERMEDIATE LINE SPEED CONTROL LEVER (8) is pushed forward, the hook will lower. When this lever is pulled backwards, the hook will raise.

> NOTE: When both control levers are operated together, a HIGH LINE SPEED is obtained.

By pushing forward on the BOOM-EXTEND RETRACT CONTROL LEVER (9), the boom sliding section will extend; when you pull this lever backwards, the boom sliding section will retract.

The boom will lower when the BOOM-RAISE /LOWER CONTROL LEVER (10) is pushed forward; the boom will raise when this lever is pulled backwards.

When the REAR WHEEL DRIVE SELECTOR CONTROL LEVER (11) is pushed fully forward and held in this position, the rear wheel drive is engaged and the control lever will remain in approximate forward position. When the rear wheel drive selector control lever is pulled backwards, the rear wheel drive is disengaged and the control lever will remain in approximate rearward position.

The FORWARD and REVERSE CONTROL LEVER (12) is used to engage the powershift forward-reverse gear box when you move the control lever in the direction of desired travel. The center position is neutral.

Pull the ENGINE SPEED CONTROL LEVER (13) backwards to increase engine speed and push the lever forward to decrease engine speed. Twist the control lever clockwise to lock it in the desired position when working the crane during lifting operations.

When traveling with the crane from one jobsite to the next, the ENGINE ACCELERATOR PEDAL (15) is used to control engine speed.

The TRANSMISSION GEAR SELECTOR LEVER (14) is used to select the desired transmission gear ratio to provide 5 speeds forward or reverse.

The hydraulically operated SERVICE BRAKE PEDAL (16) is depressed to stop the crane.

When applied, the INCHING VALVE PEDAL (17) controls the engagement of the power forward-reverse gear box. It is used in the same manner as an engine clutch to control movement of the crane whether forward or reverse.

The PARKING BRAKE LEVER (not shown) is located to the left of the operator's seat. When the lever is pulled up the parking brakes are applied; when the lever is pushed down to the horizontal position, the brakes are released.

The purpose of the various instruments is explained in the remaining part of this section; the numbers or letters in parentheses correspond to those used in figure 11-23 to indicate the location of individual instruments.

To close the circuit and energize the engine starting motor, the KEY SWITCH (1) is used.

The HOURMETER (3) records the actual hours of engine operation. It eliminates guesswork when determining proper lubrication and maintenance periods.

The COMBINATION GAGE GROUP (4) contains the engine oil pressure gage (A), the voltmeter (B), the engine temperature gage (C), and the fuel supply gage (D).

When lit, the REAR STEER INDICATOR LIGHT (5) indicates that the crane rear wheels are not

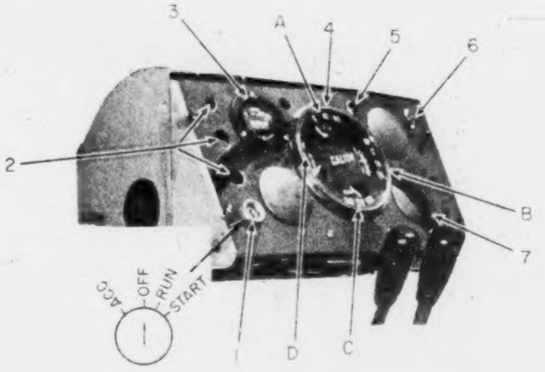

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Figure 11-23.—Instruments, Galion model 125, wheel-mounted crane.

in the straight-ahead position. When the light goes out, it indicates that the crane rear wheels are in the straight-ahead position.

Starting The Wheel-Mounted Crane Engine

In starting the Galion model 125 wheel-mounted crane engine under normal conditions, the following procedure applies:

(1) Set the parking brake.

(2) Depress the inching valve control pedal. Keep the pedal depressed when starting to reduce load on the starting motor.

(3) Move the forward-reverse control lever to the neutral position.

(4) Move the engine speed control lever to the rear about 1/3 distance and twist clockwise to lock.

(5) Turn the key switch clockwise to engage the starting motor. When the engine starts, release the key switch and the engine will run. Allow the engine to warm up, and observe the gages on the instrument panel for proper readings.

Steps For Operating

Observe the following steps to place the Galion model 125 wheel-mounted crane in motion after the engine has been started:

(1) Disengage the inching valve control panel.

(2) Position the transmission shift lever in the desired speed range.

(3) Place the forward-reverse control lever in the desired position.

(4) Release the engine speed control lever lock and move the control lever forward to idle position.

(5) Release the parking brake.

(6) Engage the inching valve control pedal by releasing the control pedal; then depress the foot accelerator pedal, which increases the speed of the engine and thus allows the crane to move to the operating area.

Stopping The Wheel-Mounted Crane

To bring the crane to a stop, proceed as follows:

(1) Decrease the engine speed by releasing foot pressure on the accelerator.

(2) Apply pressure to the footbrake pedal.

(3) Disengage the inching valve control pedal.

(4) Shift the forward-reverse control lever to neutral.

(5) Shift the transmission shift lever to neutral.

(6) Engage the crane parking brake.

Stopping The Crane Engine

To stop the crane engine, follow the procedure below.

(1) With no load on the engine, let it idle 3 to 5 minutes before shutting down. This allows the engine to cool down and permits gradual and uniform cooling of engine parts.

(2) Turn the key switch counterclockwise to the OFF position.

Operation Techniques

In operating the wheel-mounted crane, start all jobs, when possible, from relatively level ground. Avoid holes, rocks, extremely soft ground, slopes, and any other obstacle which might subject the crane to undue stress or possible overturn.

When operating on level terrain in a fixed position, the crane may be supported either on its pneumatic rubber tires or on outriggers only (outriggers set with all four wheels off the ground). Either of these positions assures firm, four-point stability during crane operations.

To pick up a load, maneuver the crane into position. Stop the crane by depressing the brake pedal. Then disengage the inching valve control pedal, place the forward-reverse shift lever in the neutral position, shift the transmission lever in the neutral position, and increase engine speed by pulling the engine speed control lever rearward and locking in the desired position. Now position the outriggers by pushing the control levers forward to the down position. Position the boom with the boom raise/lower, extend/retract, or rotation control lever. Lower the hookblock over the material to be moved by pushing the desired line speed control lever forward. In order to save undue wear on the boom and for stability, the load should be lifted with the boom in the highest position possible. When the load is attached, the rigger will signal you to raise the load. Raise the load by pulling back on the desired line speed control lever which will swing the load clear. When desirable, or necessary, you may raise the boom. If the boom is raised before the hookblock, the load will be dragged along the ground. The hookblock should not be raised so high that it becomes blocked or comes in contact with the boom head. Maximum height and rotation of the boom are controlled by you. Be aware, at all times, of the position of the boom and load.

If the load must be carried further than the boom can reach, it will be necessary to move the crane. The crane should not be moved until the load and the boom are in the proper position for travel. Remember to raise the crane outriggers if in use. In order to reduce the swing of the load, you should move the crane slowly and smoothly, avoiding sudden stops and turns.

After rigging the load for travel, place the transmission in the desired speed range, place the forward-reverse control lever in the desired position, engage the inching valve control pedal, release the footbrake pedal, release the engine speed control lever lock, move the control lever forward to the idle position, and accelerate to desired speed.

While the crane is traveling, you must not allow the load to swing to far. A swinging load causes severe strain on all parts of the crane. When there is danger of the load swinging, have a rigger attach a tag line to the load. The purpose of the tag line is to steer the load and control its swing. Normally, the rigger will walk ahead of the loaded crane with the tag line guiding the load while giving necessary signals concerning travel. When you have maneuvered the crane into position for placing the load, use the boom rotation and extend/retract controls to center the load over the spot where it is to be placed. Then lower the load by moving the desired line speed control lever to the forward position. The rigger should guide the load into position as it is lowered and unhook the load. After the load is unhooked by the rigger, operations can be resumed.

SECURING

When securing a crawler-mounted crane, position the upper revolving superstructure and attachment for traveling, walk the crane to the designated securing area, and position the crane in a safe manner. After the machine has stopped, lower the attachment to the ground, set all brakes and safety pawls, position the transmission shift lever in neutral, disengage the engine clutch, place the engine throttle control in the fuel shut-off position, and turn the key switch counterclockwise to the OFF position. Secure all doors and windows before dismounting the machine.

When securing a truck-mounted crane, position and secure the upper revolving superstructure and attachment for traveling, drive the crane to the designated securing area, and position the crane in a safe manner. After the machine has stopped, disengage the engine clutch, position the main transmission and auxiliary transmission shaft levers in neutral, engage the truck carrier parking brake, and turn the key switch counterclockwise to the OFF position. Secure all doors and windows before dismounting the machine.

When securing the wheel-mounted crane, position the outriggers (if used), hookblock, and boom for traveling; drive the crane to the designated securing area; and position the crane in a safe manner. After the machine has stopped, disengage the inching valve control pedal, move the forward-reverse shift control lever to the neutral position, shift the transmission lever to the neutral position, apply the parking handbrake, allow the engine to idle, check accessories, and stop the engine by turning the key switch counterclockwise to the OFF position.

OPERATOR'S MAINTENANCE

Every Equipment Operator is required to perform certain daily maintenance services on the crane and attachments he operates. This maintenance includes the required inspection services, lubrication, and adjustments which will maintain the crane and attachments in a safe operating condition, prevent malfunctions, and delay or avoid the need for major repairs.

General procedures used in an operator's maintenance inspection of the various components of cranes and attachments are similar to those described in previous portions of this manual for vehicles, materials-handling equipment, and tractors, and therefore need not be repeated here.

For specific instructions on the maintenance of cranes and attachments, follow the guidelines set forth in the manufacturer's lubrication charts and service manuals.

CHANGING CRANE ATTACHMENTS

The crane is a versatile piece of equipment in that it can be equipped with various attachments so that it can be used to perform a number of different operations involving construction work. The attachments include a shovel, dragline, clamshell, backhoe, piledriver, and hookblock. This section provides information that will aid you in changing attachments on cranes.

Various makes and models of cranes and attachments are available, so the procedures for changing an attachment made by one manufacturer may not be the same as for the same type of attachment furnished by another manufacturer. In that case, you can understand why only general information on changing attachments is given here. For specific instructions in changing a particular attachment, follow the procedures recommended in the operator's manual supplied by the manufacturer of the attachment concerned.

POWER SHOVEL CONVERSION

A power shovel is most widely used in quarries where digging is too hard for front-end loaders and it is not feasible to blast. Power shovel equipment includes the shovel boom proper, the dipperstick, the bucket, and the bucket trip mechanism.

There are various procedures to use when removing the shovel. These procedures are outlined in step-by-step sequence in the appropriate manufacturer's manual. A general summary is as follows:

The entire front-end assembly should be removed as a unit when changing to another attachment. The revolving superstructure should be in line with the carrier. A substantial crib should be placed under the boom near the foot end. Timbers are used to support the tip end of the boom and the dipper. After the boom foot pins have been removed, the suspension hoist and dipper trip ropes are removed. The machine can then be moved away and another attachment mounted. The time required to make the conversion from shovel to another attachment is about 6 to 8 hours.

DRAGLINE CONVERSION

Dragline buckets, attached to crane booms, are generally used for operations where extended reach is an important factor—for example, in excavating irrigation and drainage canals, in strip mining, and in gravel production. The basic machine remains on firm or undisturbed ground and is capable of digging below its own level, backing away from the excavation as the material is displaced. It is unexcelled for casting and is used extensively as a loading tool because of its large capacity and area coverage.

There are various procedures to use when removing the dragline. The procedures are outlined in step-by-step sequence in the applicable manufacturer's manual.

When converting to an attachment that does not require a boom change, such as the crane hookblock or clamshell attachment, the time required is 2 to 3 hours. When converting to the shovel or backhoe attachment the time required is 6 to 8 hours because the entire attachment must be changed.

To convert from the dragline to the shovel or backhoe, the lattice boom must be lowered onto a substantial timber crib placed to support the tip end of the boom. Another timber crib is placed to support the foot end of the boom. Depending upon the length of the boom, it may be necessary to support the boom in the center on a third timber crib.

The boom foot pins can easily be removed if they are first loosened by driving wedges between the underside of the boom foot and top of the cribbing. After removal of the pins, the suspension and hoist ropes can be removed and the dragline cable can be wound on the secondary drum for storage. The machine can now be backed away and moved to another attachment for mounting.

CLAMSHELL CONVERSION

The clamshell bucket is used as an attachment with a crane boom for vertical digging below ground level; for placement of materials at considerable height, depth, or distance; and for moving bulk materials from stockpiles to plant bins, loading hoppers, and conveyors.

There are various procedures to use when removing the clamshell. The procedures are outlined in step-by-step sequence in the applicable manufacturer's manual.

When converting to an attachment that does not require a boom change, such as the crane hookblock or dragline attachment, the time required is 2 to 3 hours. The basic components such as the tagline winder, cable drum laggings, wire ropes, and clamshell bucket may be installed on a machine already equipped with a crane boom.

To convert from the clamshell to the shovel or backhoe, the procedure is the same as described earlier for the dragline.

BACKHOE CONVERSION

The backhoe incorporates some of the characteristics of both the shovel and the dragline. Its primary function is to dig below ground level. It is capable of digging into harder material than either the dragline or the clamshell, because the weight of the boom can be used to force or crowd the bucket into the material. The digging depth of the backhoe, however, is limited by the length of the boom and stick.

The backhoe is used to dig trenches, footings, and basements. It excels in this type of work because it digs straight, vertical walls; cuts a level floor; trims corners neatly and squarely; and works from the top on dry, safe ground.

The procedure for removing the backhoe attachment is quite similar to that used in removing the shovel front-end assembly. It requires the same type of cribbing built up from timbers so that the boom foot will rest at the same height as the boom foot pins—about 4 feet high.

NOTE: Do not release any cables or pins until the front end is securely blocked, otherwise the boom or dipper handle may drop and damage the attachment. After the backhoe attachment is removed, lubricate all cables and secure with seizing.

PILEDRIVER CONVERSION

A piledriver is a machine that hammers piles made of timber, steel, concrete, or a combination of these materials into the ground. In construction work, piles are used to support buildings, retaining walls, waterfront structures, and so forth.

In removing the piledriver attachment the hammer is first removed from the leads. If a hammer with a separate pile cap is used, it is removed with the hammer and they are stored together on the attachment rack. In the case of a diesel hammer, follow the manufacturer's recommendations regarding its removal and storage.

In removing the leads the telescopic braces are removed and the foot-ends of the leads brought to rest on the ground. The boom is then lowered and, at the same time, the machine is backed away a sufficient distance to permit placing the leads horizontally on the ground. Wood blocks are placed under the boom near the tip and the weight of the boom is allowed to bear on the blocking.

Only one of the lead adapter plates need be unbolted from the top section of the leads. When this is done the boom suspension sheaves on the boom tip shaft are removed. The leads then are slid over to allow the lead adapter plate, still bolted to the top section of the leads, to slide off the end of the boom tip shaft.

The boom suspension sheaves are then replaced, the boom is raised to lifting position and the leads are picked up with the machine and placed on the attachment rack for storage.

Other attachments such as the dragline or clamshell can be installed without a boom change. With attachments such as the shovel or backhoe the boom must be changed.

HOOKBLOCK CONVERSION

A crane rigged with a hookblock attachment is a primary unit for lifting an object or load, transferring it to a new location by swinging or traveling, and then placing the load. All cranes, regardless of size, are rated on their maximum safe lifting capacity, which is based on such factors as boom length, operating radius or boom angle, type of footing, use of outriggers, amount of counterweight, size of hookblock, and position of the lift.

The procedure used to remove a hookblock attachment is generally listed step-by-step in the operator's manual supplied by the manufacturer of the attachment concerned. In most cases, the procedure will be similar to that given below.

Position the boom on cribbing which is high enough to take the "bind" from the foot pins. The boom foot pins can easily be removed if they are first loosened by driving wedges between the underside of the boom foot and top of the cribbing.

Remove the hoist line and the hookblock. If the hoist line can be used on the attachment that will replace the hookblock, then spool the line on the hoist drum; otherwise remove the line.

Next remove the boom hoist pendant cables and allow the bridle sheave system to rest on the boom. Then remove the boom suspension cable by loosening the outside anchor point and use the engine power to unreeve the line from the sheaves. If the suspension line cannot be used on the attachment that will replace the hookblock, then it should be removed, tagged, and stored with the boom.

The boom stops should be removed from the superstructure and also stored with the boom.

In some cases, the hoist drum laggings may have to be removed and replaced with other types. If so, those which are removed should be tagged and stored with the crane boom.

The total time required to remove a complete attachment will vary, depending upon the size of the equipment being worked on, but will usually take three men approximately 2 to 3 hours.

CRANE AND ATTACHMENT SAFETY

Statistics on accidents show that a free moving power crane is one of the most destructive machines used in the Navy as well as in private industry. Over one-third of all crane accidents result in fractured, broken, or amputated limbs. Over one-third of those injured are crane operators; more than one-fourth are crewmembers other than operators. This means, ironically enough, that the people who sustain the majority of the injuries inflicted by cranes are the very ones who can do the most to prevent them.

Most crane accidents are preventable simply because they are caused by situations, conditions, or actions which are under control of the operating crew. The term "preventable accident" is illogical, however, for if an accident is preventable it is not, in fact, an accident, but results from an act of omission or commission on somebody's part.

Most crane work is, or should be, a coordinated activity of a team of skilled technicians and workers. The lives and well being of the whole team are in the hands of each member of the team during a continually shifting scene requiring constant judgment and responsibility. The operator, oiler, rigger, signalman, flagman, and anyone else working on the rig, all assume and transfer back and forth to each other control of lifts, movements, and other activities.

It is, therefore, vitally important that these control responsibilities be clearly defined, and that the procedure for assuming and transferring them be laid out in advance and thoroughly understood by all hands. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency signal belongs to anyone in the vicinity who believes such a signal is necessary. Hand signals used during crane operations are depicted in appendix I.

Some of the hazardous conditions and practices encountered in the operation and maintenance of cranes and attachments are listed below. Make sure you study this list carefully, noting particularly the hazards connected with your type of work. Heed seriously the instructions and warnings of your project petty officer regarding safe practices to be followed during operation and maintenance, and make every effort to avoid accidents from any of the major causes listed:

1. Backing and turning machines, swinging booms, lowering buckets, and performing similar operations without looking, warning, or signaling.
2. Getting on and off equipment carelessly while it is in operation, or riding equipment when not authorized to do so.
3. Operating equipment with defective brakes, clutches, cables, or other improperly functioning parts.
4. Working or walking under lifts, buckets, or loads.
5. Failure to adjust controls properly before attempting to crank an engine.
6. Oiling, adjusting, or repairing equipment while it is in operation.
7. Using equipment with unguarded or inadequately guarded engine fans and other dangerous moving parts.
8. Failing to use protective devices or clothing such as goggles, safety shoes, gloves, and hard hats.
9. Failing to properly block equipment or heavy parts while repairing equipment.
10. Operating equipment in a thoughtless or unsafe manner, such as moving too fast over rough ground or working too near the edge of a soft fill.
11. Operating cranes too close to powerlines without adequate watches and supervision.
12. Failing to secure equipment, brakes, booms, and movable parts before repairing, leaving, or moving the machine
13. Poor housekeeping either on equipment itself or in the operating area.
14. Overloading equipment.
15. Obstruction to the free passage of boom or the load of the crane.
16. Operators not familiar with equipment.
17. Operating on uneven ground.
18. Lifting load to an unknown greater radius.
19. Boom contacting high tension wires.
20. Using weight indicators without checking recommended usage data.
21. Not changing capacity charts on cranes when different boom lengths are used.
22. Use of boom with bent or dented chord member.

23. Use of weight indicators as weighing devices.
24. Use of frame for towing.

Some major hazards due to UNSAFE EQUIPMENT that you may encounter in the operation of cranes used as a shovel, dragline, clamshell, backhoe, and piledriver are:

1. Dropping or slipping of load.
2. Breaking of cables.
3. Non-use of outriggers.
4. Faulty or poorly adjusted brakes and clutches.
5. Clutch or brake slipping and allowing boom radius to increase.
6. Job exceeding safe boom radius.
7. Job exceeding capacity of crane.
8. Operating with bent or damaged boom.
9. Non-use of mousing or safety-type hooks.

Every crane must be inspected and tested annually for safe load capacity, in accordance with command policies. The safe load chart should be posted in a prominent place in the cab near the operator, who must familiarize himself with the safe working load and tipping capacity of that particular crane.

Crane operators are responsible for knowing the limitations and capacities of the cranes they operate. You must not attempt, nor will you be required or permitted, to operate a crane either in an unsafe manner or when known to be in an unsafe condition. The operator should promptly report any malfunctioning or other defects in the equipment to his leading petty officer.

You, as an operator, have the authority to stop and refuse to handle loads until you are assured all safety requirements have been met.

All cranes must be equipped with appropriate fire extinguishers which must be maintained ready to use.

Tools and other maintenance items must be kept in the toolbox provided.

Avoid leaving the boom in a raised position with no load in a high wind. Failure to do this could cause the boom to be blown backwards.

In case a load strikes the boom or the boom strikes an object, the boom should be lowered immediately and carefully examined for bent or damaged members. A slight bend in the boom structure can cause it to fail and collapse.

You should never travel and rotate simultaneously with a near-capacity load. If the travel surface is uneven the machine may upset. When necessary to move a near-capacity load, it should be placed on a truck or railroad car and then unloaded at the new location.

When lifting a critical or unstable load, the outriggers should be set. If the outriggers are set and a load should be dropped, the kickback will not tip the crane backwards.

Crane booms should never be operated near high tension powerlines if it can be avoided. If work must be done in their vicinity, contact should be made with the electricians to have the powerlines de-energized before starting work. If this is not possible, then make sure that at no time the boom or hoisting lines come closer than 10 feet of the high tension lines while you are operating the crane. You should not depend on any chain or other grounding device dragging along the ground to give protection against electrical current discharges through the crane. Such a device is not a safe means for grounding a crane and it gives you a false sense of security.

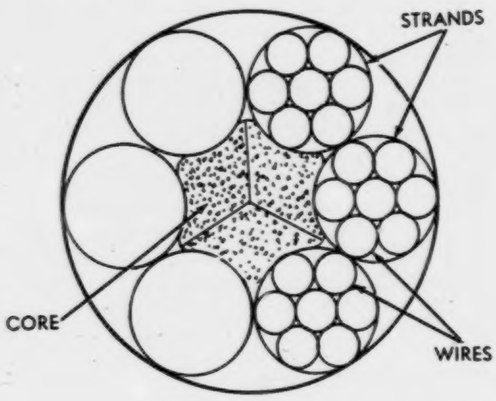
The electrocution hazard created when a crane boom touches a powerline is an extremely serious one. In case a boom or cable does touch a high tension wire, creating a short, you should either stay in the crane KEEPING YOUR HANDS OFF THE CONTROLS, or JUMP CLEAR of the machine. You should never dismount from the machine by climbing down the side, thereby permitting your body to come in contact with the machine and the ground at the same time. You should also warn all other crewmembers not to touch the machine or attachments that are in contact with the high tension line.

WIRE ROPE

You will find that many of the movable parts on cranes and attachments are moved by means of wire rope. We will discuss types of wire rope, their characteristics, construction, and usage. Instruction also is provided on safe working load, use of attachments and fittings, and various procedures applicable to the care and handling of wire rope.

CONSTRUCTION

Wire rope consists of three parts: wires, strands, and core (fig. 11-24). In the manufacture of rope, a number of wires are laid together to form the STRAND. Then a number



29.172
Figure 11-24. — Parts of wire rope.

of strands are laid together around a CORE, to form the rope.

The basic unit of wire rope construction is the individual wire, which may be made of steel, iron, or other metal, in various sizes. In making a rope, the number of wires to a strand will vary, depending on the purpose for which the rope is intended. Wire rope is designated by the number of strands per rope and the number of wires per strand. Thus, a 1/2" 6 x 19 rope will have 6 strands with 19 wires per strand, but will have the same outside diameter as a 1/2" 6 x 37 wire rope, which will have 6 strands with 37 wires of much smaller size per strand.

Wire rope made up of a large number of small wires is flexible, but the small wires are easily broken so the wire rope is not resistant to external abrasion. Wire rope made up of a smaller number of larger wires is more resistant to external abrasion but is less flexible.

The CORE — the element around which the strands are laid to form the rope — may be a hard fiber (such as manila, hemp, plastic, paper, asbestos, or sisal), a wire strand, or an independent wire rope. Each type of core serves the same basic purpose, that of affording support to the strands laid around it.

A FIBER CORE offers the advantage of increased flexibility. In addition, it serves as a cushion to reduce the effects of sudden strain and acts as a reservoir for the oil necessary for lubrication of the wires and strands to reduce friction between them. Wire rope having a fiber core is used in places where flexibility on the part of the rope is important.

A WIRE STRAND CORE not only provides more resistance to heat than a fiber core, but also adds about 15 percent to the strength of the rope. On the other hand, the wire strand makes the rope less flexible than when a fiber core is used.

AN INDEPENDENT WIRE ROPE CORE is a separate wire rope over which the main strands of the rope are laid. It usually consists of six 7-wire strands laid around either a fiber core or a wire strand core. This type of core gives the rope additional strength, provides support against crushing, and supplies maximum resistance to heat.

Wire rope may be fabricated by either of two methods. If the strands or wires are shaped to conform to the curvature of the finished rope prior to laying up, the rope is termed PREFORMED. If they are not shaped before fabrication, the rope is termed NONPREFORMED. When cut, preformed wire rope tends not to unlay, and it is more flexible than nonpreformed wire rope. With nonpreformed wire rope, the twisting process produces a stress in the wires, and when it is cut or broken the stress causes the strands to unlay. In nonpreformed wire, unlaying is rapid and almost instantaneous, and could cause serious injury to someone not familiar with it.

GRADES OF WIRE ROPE

Wire rope is manufactured in a number of different grades, three of which are: mild plow steel, plow steel, and improved plow steel.

MILD PLOW STEEL rope is tough and pliable. It can stand up under repeated strain and stress, and has a strength of from 200,000 to 220,000 pounds per square inch (psi). These characteristics make its use desirable for cable tool drilling and other purposes where abrasion is encountered.

PLOW STEEL wire rope is unusually tough and possesses great strength. This steel has a tensile strength (resistance to lengthwise stress) of 220,000 to 240,000 psi. This rope is suitable for hauling, hoisting, and logging.

IMPROVED PLOW STEEL rope is one of the best grades of rope available, and most — if not all — of the wire rope used in your work will probably be made of this material. It is stronger, tougher, and more resistant to wear than either plow steel or mild plow steel. Each square inch of improved plow steel can stand a strain of 240,000 to 260,000 pounds. It is especially useful for heavy duty service, such as power cranes with excavating and weight-handling attachments.

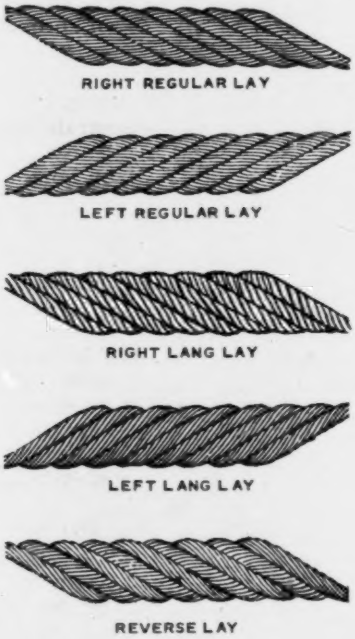
WIRE ROPE LAYS

The term LAY refers to the direction of the twist of the wires in a strand and the strands in the rope. In some instances both the wires in the strand and the strands in the rope are laid in the same direction,. and in other instances in the opposite direction, depending on the intended use of the rope. Most manufacturers will specify types and lays of wire rope to be used on their particular piece of equipment. Be sure and consult the operator's manual as to proper application.

Five different lays of wire rope currently in use are illustrated in figure 11-25. The following explanations will help you recognize and identify each of the five types shown.

RIGHT REGULAR LAY: In this type, the wires in the strands are laid to the left, while the strands in the rope are laid to the right.

LEFT REGULAR LAY: In this case, the wires are laid up to the right to make the strands, then the strands are laid up to the left to form the rope. (In this lay, each step of fabrication is exactly opposite from the right regular lay.)



29.173

Figure 11-25. — Wire rope lays.

RIGHT LANG LAY: Here the wires in the strands and the strands in the rope are both laid up to the right.

LEFT LANG LAY: With this type, the wires in the strands and the strands in the rope are also laid in the same direction, but in this instance the lay is to the left (rather than in the right lang lay).

REVERSE LAY: The wires in one strand are laid up to the right, the wires in the adjacent strand are laid up to the left; the wires in the next strand are to the right; and so forth, with alternate directions from one strand to the other. Then all strands are laid to the right.

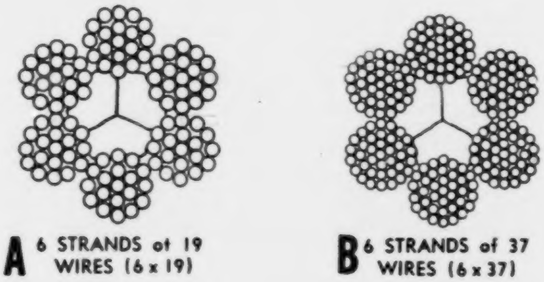
TYPES OF WIRE ROPE

The main types of wire rope used by the Navy consist of 6, 7, 19, 24, or 37 wires in each strand. Usually, the rope has 6 strands laid around a fiber or steel center.

Two common types of wire rope, 6 x 19 and 6 x 37 rope, are illustrated in figure 11-26. The 6 x 19 type, having 6 strands with 19 wires in each strand, is commonly used for rough hoisting and skidding work where abrasion is likely to occur. The 6 x 37 wire rope, having 6 strands with 37 wires in each strand, is the most flexible of the standard 6-strand ropes. For this reason, it is particularly suitable when small sheaves and drums are to be used, such as on power cranes and similar machinery.

MEASURING WIRE ROPE

Wire rope is designated as to size by its diameter in inches. The true diameter of a wire


A 6 STRANDS of 19 WIRES (6 x 19)
B 6 STRANDS of 37 WIRES (6 x 37)

29.173(29C)

Figure 11-26. — (A) 6 x 19 wire rope; (B) 6 x 37 wire rope.

rope is considered as being the diameter of the circle which will just enclose all of its strands. The correct, as well as incorrect, method of measuring wire rope is illustrated in figure 11-27. Note, in particular, that the RIGHT WAY is to measure from the top of one strand to the top of the strand directly opposite it. The wrong way, as you will note, is to measure across two strands side by side.

Use calipers to take the measurement; if they are not available, an adjustable wrench will do.

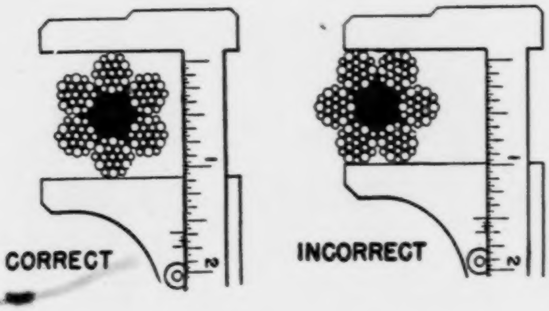
To ensure an accurate measurement of the diameter of a wire rope, always measure the rope at three places, at least 5 feet apart. Use the average of the three measurements as the diameter of the rope.

SAFE WORKING LOAD

The term SAFE WORKING LOAD (SWL), as used in reference to wire rope, means the load that can be applied and still obtain most efficient service and also prolong the life of the rope. There are a number of rule-of-thumb formulas which may be used to compute strength of wire rope. The one recommended by the Naval Facilities Engineering Command (NAVFAC) is:

$$\text{SWL (in tons)} = D^2 \times 4.$$

In this formula, D represents the diameter of the rope in inches. Suppose you want to find the SWL of a 2-inch rope. Using the formula above, your figures would be:



29.173(133E)

Figure 11-27.—Correct and incorrect methods of measuring wire rope.

$$\text{SWL} = (2)^2 \times 4$$
$$\text{SWL} = 4 \times 4 = 16$$

The answer is 16, meaning that the rope has an SWL of 16 tons.

It is important to remember that any formula for determining SWL is ONLY A RULE OF THUMB. In computing the SWL of old rope, worn rope, or rope which is otherwise in poor condition, you should reduce the SWL as much as 50 percent, depending on the condition of the rope.

WIRE ROPE FAILURE

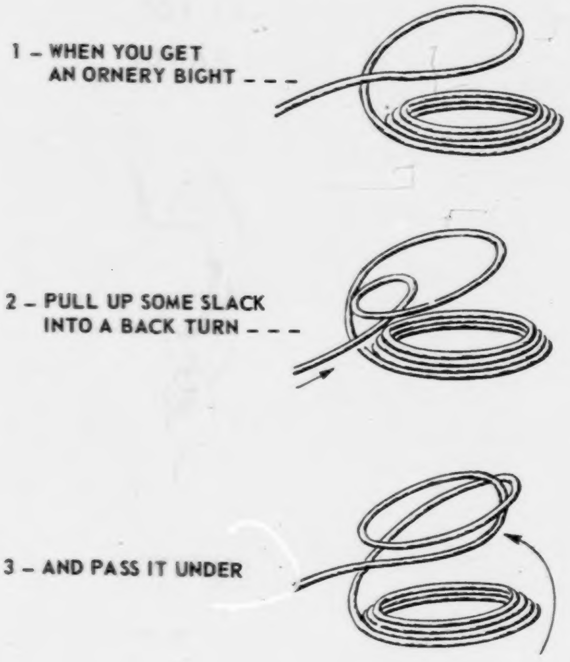
Some of the common causes of wire rope failure are listed below.

1. Using incorrect size, construction, or grade.
2. Dragging over obstacles.
3. Improper lubrication.
4. Operating over sheaves and drums of inadequate size.
5. Overriding or cross-winding on drums.
6. Operating over sheaves and drums with improperly fitted grooves or broken flanges.
7. Jumping off sheaves.
8. Subject to acid fumes.
9. Improperly attached fitting.
10. Allowing grit to penetrate between the strands, promoting internal wear.
11. Subjecting to severe or continuing over- d.
12. Excessive fleet angle.

HANDLING AND CARE

To render safe, dependable service over a maximum period of time, wire rope must be given the care and upkeep necessary to maintain it in good condition. Various procedures applicable to the care and handling of wire rope are given in the following subsections.

It is recommended that you not only study these procedures carefully but, it is more important that you also put them into practice on your job. A knowledge of the procedures, as well as experience in using them, will help you do a better job NOW; and in the long run, the life of the wire rope will be longer and more useful.


1 - WHEN YOU GET AN ORNERY BIGHT - - -
2 - PULL UP SOME SLACK INTO A BACK TURN - - -
3 - AND PASS IT UNDER

118.6
Figure 11-28.—Throwing a back turn on make wire lie down.

Coiling and Uncoiling

Once a new reel has been opened, it may be coiled or faked down like line. The proper direction of coiling is COUNTERCLOCKWISE for LEFT LAY wire rope and CLOCKWISE for RIGHT LAY rope. Because of the general toughness and resilience of wire, however, it has a tendency now and then to resist being coiled down. When this occurs, it is useless to fight the wire by forcing down the stubborn turn; it will only spring up again. But if it is thrown in a back turn, as shown in figure 11-28, it will lie down properly. A wire rope, when faked down, will run right off like line; but when wound in a coil, it must always be unwound.

Wire rope has a strong tendency to kink during uncoiling or unreeling, especially if it has been in service for a long time. Keep in mind that a kink can cause a weak spot in the rope, which will wear out quicker than the rest of the rope.

A good method for unreeling wire rope is to run a pipe or rod through the center and mount the reel on drum jacks or other supports so that the reel is off the ground. (See fig. 11-29.) In this way, the reel will turn as the rope is unwound, and the rotation of the reel will help keep the rope straight. During unreeling, pull the rope straight forward, as shown in figure 11-29, and try to avoid hurrying the operation. As a safeguard against kinking, NEVER unreel wire rope from a reel that is stationary.

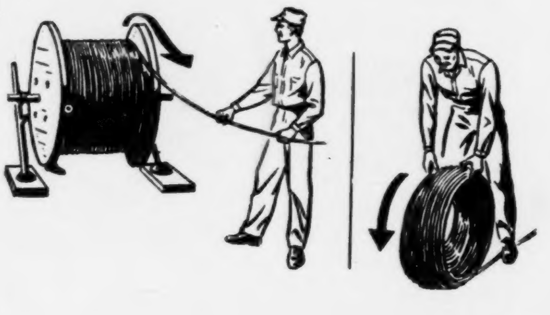
To uncoil a small coil of wire rope, simply stand the coil on edge and roll it along the ground like a wheel or hoop, as illustrated in figure 11-29. NEVER lay the coil flat on the floor or ground and uncoil it by pulling on the end, because such practice is likely to cause kinks or twists in the rope.

To re-reel wire rope back onto a reel or a drum you may have difficulty unless you remember that it tends to roll in the opposite direction of the lay. A right-lay wire rope, for example, tends to roll to the left.

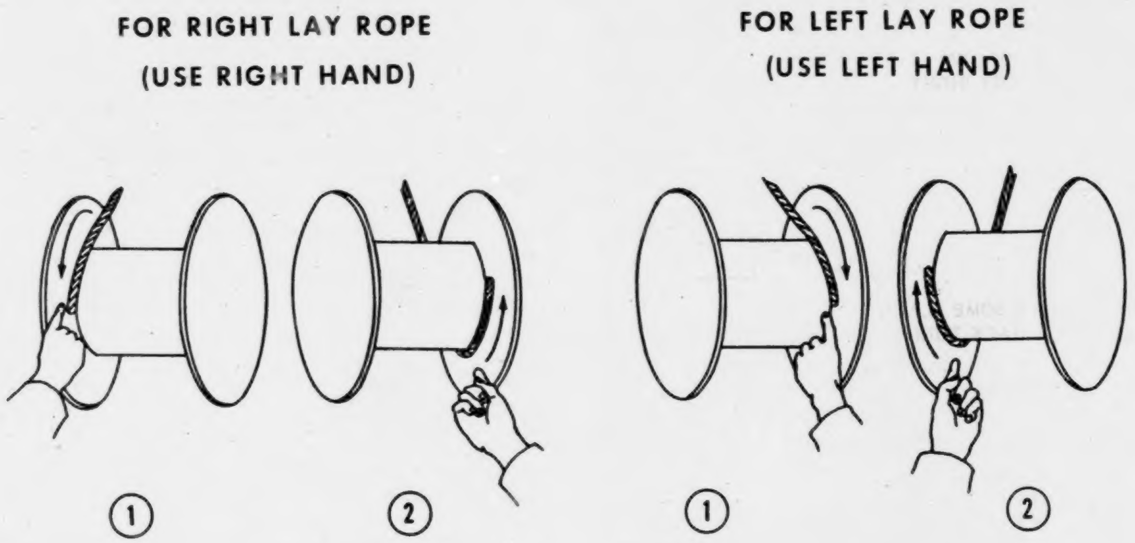
Closely observe figure 11-30, which shows drum winding diagrams for selection of the proper lay of rope. When putting wire rope onto a drum, you should have no trouble if you are familiar with the methods of overwinding and underwinding shown in the illustration. When wire rope is run off one reel onto another reel, or onto a winch or drum, it should be run from TOP TO TOP or from BOTTOM TO BOTTOM, as shown in figure 11-31.

Kinks

If a wire rope should form a loop, never try to pull it out by putting strain on either



29.174
Figure 11-29.—(Left) Unreeling wire rope. (Right) Uncoiling wire rope.



FOR OVERWIND ON DRUM:

The palm is down, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the left-side flange.
The wind of the rope must be from left to right along the drum.

FOR UNDERWIND ON DRUM:

The palm is up, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the right-side flange.
The wind of the rope must be from right to left along the drum.

FOR OVERWIND ON DRUM:

The palm is down, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the right-side flange.
The wind of the rope must be from right to left along the drum.

FOR UNDERWIND ON DRUM:

The palm is up, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the left-side flange.
The wind of the rope must be from left to right along the drum.

If a smooth-face drum has been cut or scored by an old rope, the methods shown may not apply.

115.289

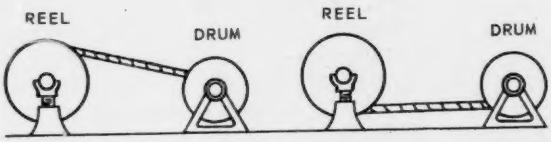
Figure 11-30.—Drum windings diagram for selection of proper lay of rope.

part. As soon as a loop is noticed, uncross the ends by pushing them apart. (See step 1 in fig. 11-32.) This reverses the process that started the loop. Now, turn the bent portion over and place it on your knee or some firm object and push downward until the kink straightens out somewhat. Then lay it on a flat surface and pound it smooth with a wooden mallet.

If a heavy strain has been put on a wire rope with a kink in it, the rope can no longer be trusted. Replace the wire rope altogether.

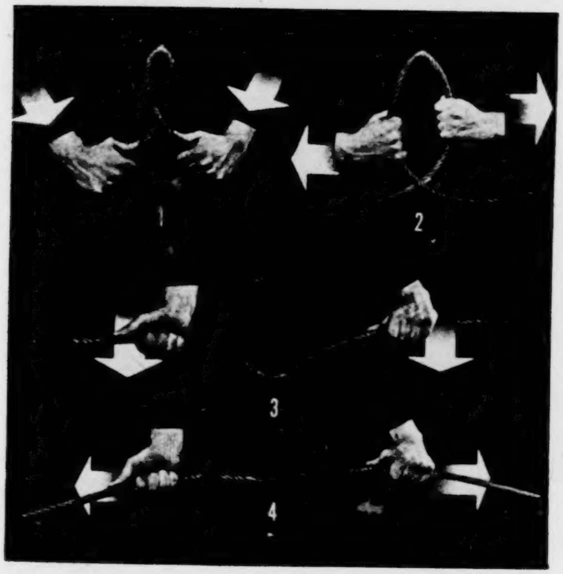
Reverse Bends

Whenever possible, drums, sheaves, and blocks used with wire rope should be placed



80.18

Figure 11-31.—Transferring wire from reel to drum.



80.20
Figure 11-32.—The correct way to take out a loop in wire rope.

Table 11-1.—Suggested Minimum Tread Diameter of Sheaves and Drums

Rope diameter in inches	Minimum tread diameter in inches for given rope construction*			
	6 x 7	6 x 19	6 x 37	8 x 19
1/4	10 1/2	8 1/2	---	6 1/2
3/8	15 3/4	12 3/4	6 3/4	9 3/4
1/2	21	17	9	13
5/8	26 1/4	21 1/4	11 1/4	16 1/4
3/4	31 1/2	25 1/2	13 1/2	19 1/2
7/8	36 3/4	29 3/4	15 3/4	22 3/4
1	42	34	18	26
1 1/8	47 1/4	38 1/4	20 1/2	29 1/4
1 1/4	52 1/2	42 1/2	22 1/2	32 1/2
1 1/2	63	51	27	39

*Rope construction is in strands times wires per strand.

80.260

so as to avoid reverse or S-shaped bends. Reverse bends cause an unnecessary amount of shifting of the individual wires and strands, increasing wear and fatigue. Where a reverse bend is necessary, the drums and blocks affecting the reversal should be of larger diameter than that ordinarily used and should be spaced as far apart as possible.

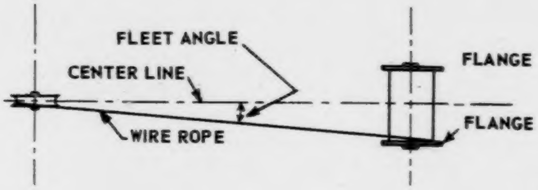
Sizes of Sheaves

It is not possible to prescribe an absolute minimum size of wire rope sheaves, owing to the number of factors involved. Experience has shown, however, that the diameter of a sheave should NEVER BE LESS THAN 20 TIMES THE DIAMETER OF THE WIRE ROPE. An exception to this is 6 x 37 wire, for which a smaller sheave can be used because of the greater flexibility of this wire rope. As indicated in table 11-1, the construction of the wire rope has a great deal to do with determining the minimum diameter of sheaves to be used. The stiffer the wire rope, the larger the sheave diameter required.

Another thing to remember in connection with sheaves and drums is to keep the FLEET ANGLE as small as you can. The fleet angle is formed by running wire rope between a sheave and a hoisting drum whose axles are parallel to each other, as shown in figure 11-33. Too large a fleet angle can cause the wire to climb the flange of the sheave and may even break the flange. It can also cause the wire to climb over itself on the drum. When setting up the sheave and drum, keep them far enough apart to make the fleet angles small. About 20 times the width of the drum should be the minimum distance between the drum axle and the sheave axle. This will ensure a minimum of 1-1/2 to 2 degrees fleet angle. (The width of the drum is measured from flange to flange.)

Seizing and Cutting

Great care is exercised in the manufacture of wire rope to lay each wire in the strand and each strand in the rope under uniform tension. If the ends of the rope are not secured properly, the original balance of tension will be disturbed and maximum service will not be obtained, because some strands will carry a greater portion of the load than others. Before cutting steel wire rope, place three sets of seizing on



127.48
Figure 11-33. — Fleet angle.

each side of the point where the rope is to be cut. A rule-of-thumb for determining the size, number, and distance between seizing is as follows:

1 x the diameter for the width of the seizing
2 x the diameter for the distance between seizings
3 x the diameter for the number of seizings

For permanent seizings the seizing wire should be inserted through the wire rope by using a pricker to form an opening; the seizing wire is then laid along in the valley between strands for the width of the seizing, and then turns are taken back toward the remaining end.

To make a temporary wire rope seizing, wind on the seizing wire uniformly, using tension on the wire. After taking the required number of turns, as in step 1 in figure 11-34, twist the ends of the wires counterclockwise by hand, so that the twisted portion of the wires is near the middle of the seizing, as in step 2. Grasp ends with end-cutting nippers and twist up slack as in step 3. Do not try to tighten seizing by twisting. Draw up on seizing as in step 4. Again twist up the slack, using nippers as in step 5. Repeat steps 4 and 5 if necessary. Cut ends and pound them down on the rope as in step 6. If the seizing is to be permanent, or if the rope is 1-5/8 inches or more in diameter, use a serving bar or iron to increase tension on the seizing wire when putting on the turns.

Wire rope can be cut successfully by a number of methods. One effective yet simple method is that of using a hammer-type wire rope cutter (see fig. 11-35). (Remember that all wire must be seized before it is cut.) For best results in using this method, place the rope in the bottom of the cutter, as illustrated, so that the blade comes between the two central seizings. With the blade down against the rope

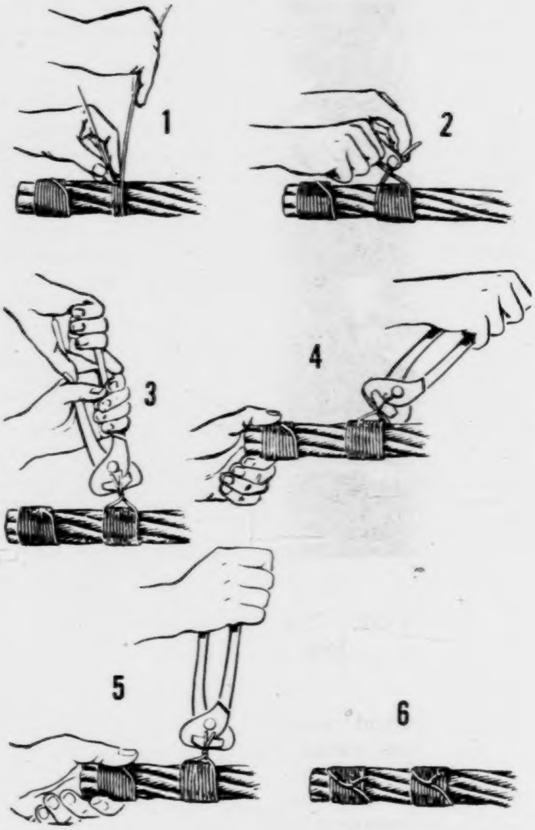


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Figure 11-34. — Putting a seizing on a wire rope.

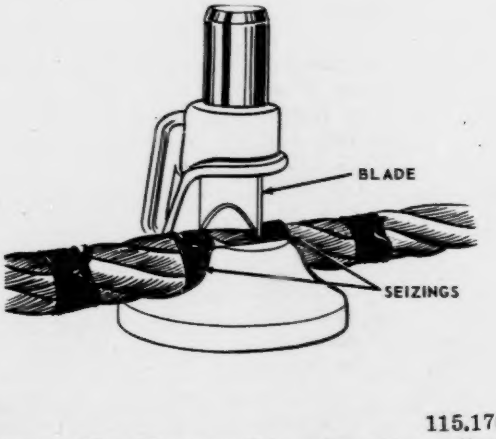

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Figure 11-35. — Hammer-type wire rope cutter.

at the location of the cut, strike the top of the blade sharply several times with a sledge hammer.

Wire rope can be cut easily with a hydraulic wire rope cutter. This device works basically like a hydraulic jack; as you pump the handle, a cutter severs the wire rope.

Bolt cutters are only suitable for cutting wire of fairly small diameter, but the cutting torch will cut wire of any diameter.

Care of Wire Rope

Wire rope bending around winch drums and sheaves will wear like any other metal article, and for this reason lubrication is just as important to an operating wire rope as it is to any other piece of working machinery. The proper functioning of a wire rope depends upon freedom of movement, with a minimum of friction, of the individual wires and strands in relation to one another. Friction caused by lack of lubrication or corrosion, or both, will seriously shorten the service life of the wire rope.

Deterioration caused by corrosion is more dangerous than that caused by wear, simply because corrosion commonly affects the inside wires, and this makes it more difficult to detect by inspection. Deterioration caused by wear can be detected by examining the outside wires of the wire rope, because these wires become flattened and reduced in diameter as the wire rope wears. Any wire rope in which the outside wires are worn to less than 75 percent of their original diameter should be replaced.

Both internal and external lubrication are required to protect a wire rope against wear and corrosion. Internal lubrication can be properly applied only when the wire rope is being manufactured, and manufacturers customarily coat every wire with a rust-inhibiting lubricant as it is laid into the strand. The core is also lubricated in the course of the manufacturing process.

Lubrication applied in the field is designed not only to maintain surface lubrication, but also to prevent the dissipation of the internal lubrication provided by the manufacturer. The Navy issues an asphaltic petroleum oil which must be heated before using. This lubricant is known as LUBRICATING OIL—CHAIN, WIRE ROPE, AND EXPOSED GEAR. There are two types of this oil. Type I, REGULAR, is used when service conditions do not require a rust preventive. This is the case only for interior wires, such as elevator wires, which are not exposed to weather. Type II, PROTECTIVE, is both a lubricant and an anticorrosive. It comes in three grades: Grade A, for use in cold weather (60°F and below); Grade B, for use in warm weather (between 60° and 80°F); and Grade C, for use in hot weather (80°F and above). The oil is issued in 25-lb and 35-lb buckets and in 100-lb drums, and it can be applied with a stiff brush, or by drawing the wire rope through a trough containing hot lubricant as shown in figure 11-36. Frequency of application depends upon service conditions; as soon as the last coating has appreciably deteriorated, it should be renewed.

Never lubricate wire rope being used to operate a dragline and other such attachments that normally bring the wire rope in contact with soils. The reason is that the lubricant will pick up fine particles of the material and the resulting abrasive action will be detrimental to both the wire rope and sheave.

As a safety precaution, always wipe off any excess when lubricating wire rope. This is especially important where hoisting equipment is involved. Too much lubricant is liable to get into brakes or clutches, causing them to fail. While in use, the motion of machinery may sling excess oil around over crane cabs and onto catwalks, making them unsafe to work on.

WIRE ROPE ATTACHMENTS

A considerable number of ATTACHMENTS can be fitted to the ends of wire rope so that the rope can be connected to other wire ropes, pad eyes, or equipment. The attachment used most frequently to attach dead ends of wire ropes to pad eyes or similar fittings on earthmoving rigs is the WEDGE SOCKET shown in figure 11-37. The socket is applied to the bitter end of the wire rope as shown in the figure. Remove the pin and knock out the wedge first. Then pass the wire rope up through the socket and lead enough of it back through the socket to allow at least 2 inches of the bitter end to extend below the socket upon completing the attachment, as shown in figure 11-38. Next, replace the wedge, and haul on the bitter end of the wire rope until the bight closes around the wedge as shown in figure 11-38. A strain on the standing part will tighten the wedge. A great advantage of the wedge socket is the fact that to remove

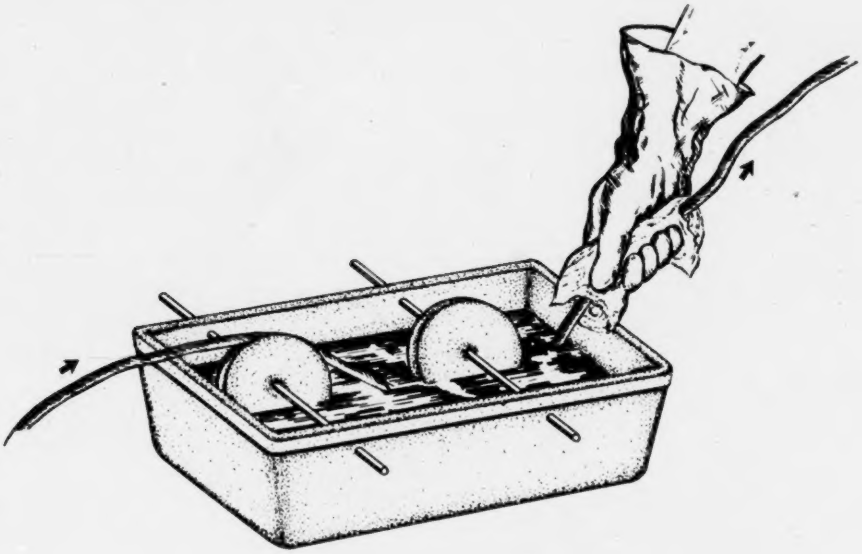

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Figure 11-36.—Method of field lubrication.

it you need only to drive out the wedge. It should be noted, however, that the strength of a wedge-type socket is such that the overall strength of a rope having a socket attachment is reduced by about 30 percent, but if one wire rope clip is used, it is only reduced by 20 percent. The safe working load of the rope must, of course, also be reduced accordingly.

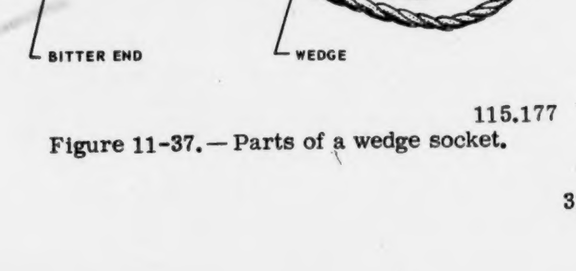

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Figure 11-37.—Parts of a wedge socket.

The best method for attaching a closed or open socket in the field is by speltering. The term SPELTERING means to attach the socket to the wire rope by pouring hot zinc. (See fig. 11-39.) Forged steel speltered sockets are as strong as the wire rope itself, and are required on all cranes that are used primarily for lifting personnel, as well as for lifting ammunition, acids, and other extremely dangerous materials. Cranes lifting foodstuff and other general supplies may use forged steel wedge or swaged sockets.

A common method of making an eye in the end of a wire rope is by the use of WIRE ROPE CLIPS like those shown in figure 11-40. The U-shaped part of the clip, with the threaded ends, is called the U-BOLT; the other part is called the SADDLE (OR RODDLE). The saddle is stamped with the diameter of the wire rope the clip will

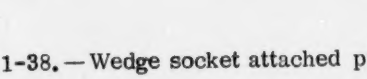

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Figure 11-38.—Wedge socket attached properly.

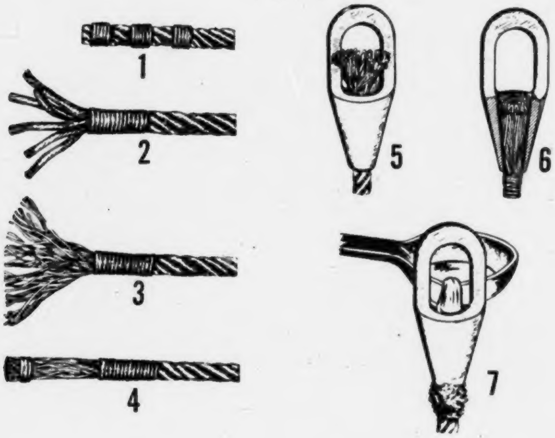

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Figure 11-39.—Speltering a closed or basket socket.

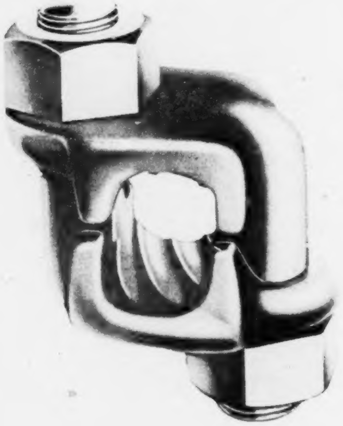

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Figure 11-41.—Twin-base wire rope clip.

fit. Always place a clip with the U-bolt on the bitter end, not on the standing part of the wire rope. If clips are attached incorrectly, the standing part (live end) of the wire rope will be distorted or will have mashed spots.

Following is a simple formula for wire rope clips:

3 x wire rope diameter + 1 = Number of clips
6 x wire rope diameter = Spacing between clips

Another type of wire rope clip is the TWIN-BASE clip shown in figure 11-41. Both parts of this clip are shaped to fit the wire rope; consequently, the clip cannot be put on wrong and it is less damaging to wire rope than the U-bolt clip. It also allows for a clear 360 degree swing with the wrench when the nuts are being tightened. When an eye is made in a wire rope, the metal fitting called a THIMBLE is usually placed in the eye, as shown in figure 11-40, to protect the eye against wear.

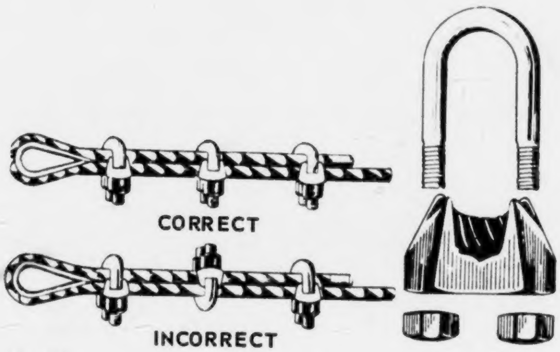

Figure 11-40.—Wire rope clips. 56.226

After the eye made with clips has received an initial heavy strain, the nuts on the clips must be retightened. Periodic checks should be made afterwards for tightness, and also for damage to the rope that might be caused by the clips.

REEVING WIRE ROPES

Usually the manufacturer's manual pertaining to a particular type of power crane and its attachments will tell you the size, length, type, and makeup of each of the wire ropes required for that particular rig. The manufacturer's manual will also contain diagrams, supplemented where necessary by detailed explanatory text, which show exactly how to reeve each wire rope on that rig.

SLINGS

Slings are widely used in the moving and hoisting of heavy loads. Some types of slings can be obtained already made. Slings may be made of fiber line, wire rope, or chain.

FIBER LINE slings offer the advantage of flexibility and more protection of the finished material than is provided by wire rope slings. At the same time, fiber line slings are not as strong as wire rope or chain slings. Furthermore, fiber line is more likely to be damaged by sharp edges on the material being hoisted than is wire rope or chain slings.

WIRE ROPE slings offer advantages of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of many hoisting jobs in steelwork. Thus you will use wire rope slings more frequently than fiber line or chain slings.

CHAIN SLINGS are frequently used in hoisting and moving heavy steel items such as rails, pipes, beams, and angles. They are also especially desirable for slinging hot loads and in handling loads with sharp edges which might cut wire rope.

Using Wire Rope and Fiber Line Slings

Three types of fiber line and wire rope slings commonly used for lifting a given load are the endless, single leg, and bridle slings.

An ENDLESS SLING, usually referred to simply as SLING, can be made simply by splicing together the ends of a piece of fiber line or wire rope so that an endless loop is formed. An endless sling is easy to handle and can be used as a CHOKER HITCH. (See fig. 11-42.)

A SINGLE LEG SLING, commonly referred to as a STRAP, can be constructed by forming a spliced eye in each end of a piece of fiber line or wire rope. Sometimes the ends of a piece of wire rope are spliced into eyes around thimbles, and one eye is fastened to a hook with a shackle. With this arrangement, the shackle and hook are removable.

The single leg sling may be used as a choker hitch (fig. 11-43) in hoisting by passing one eye through the other eye and over the hoisting hook. The single leg sling also is useful as a double anchor hitch (fig. 11-43). You will find the double anchor hitch desirable for hoisting drums or other cylindrical objects where it is necessary that the sling tighten itself under strain and lift by friction against the sides of the object.

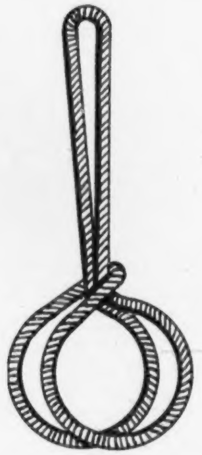

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Figure 11-42.— Method of using endless sling.

Single leg slings can be used to make various types of BRIDLES. Three common uses of bridles are illustrated in figure 11-44. Either two or more single slings may be used for a given combination. Also, if an individual sling is not long enough for the job at hand, two of the single slings can be combined to form a longer single sling.

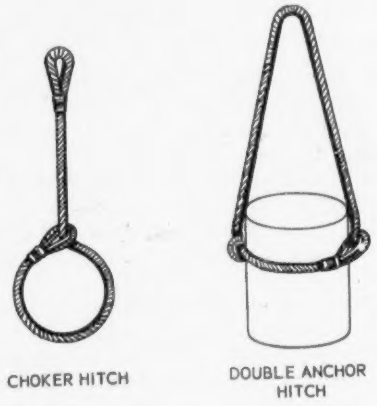

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Figure 11-43.—Methods of using single leg slings.

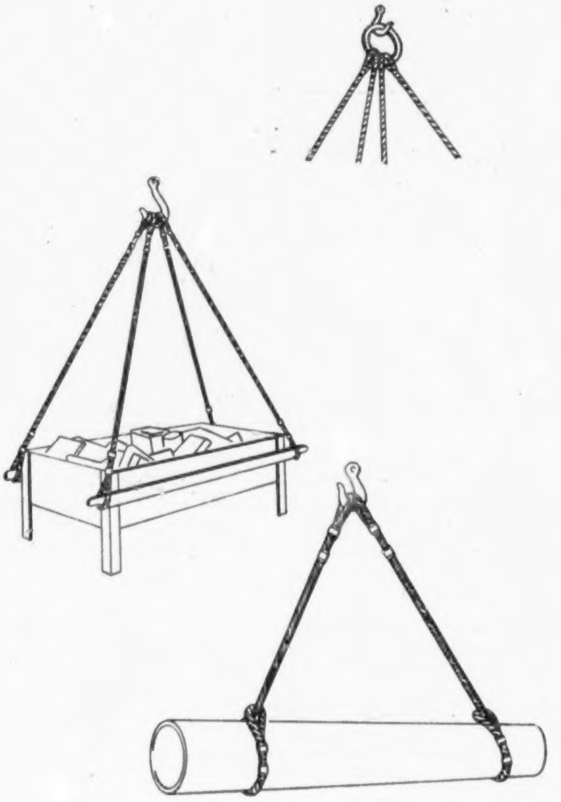

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Figure 11-44. — Bridles.

It is advantageous to have matched sets of slings (that is, two or more equal lengths) so that when it is necessary to use more than one to hoist a load the strain will be equal and the load will come up evenly. Also, slings that are of equal length should be marked for ease of identification. Painting the eyes of equal length slings the same color is one way of doing this.

In lifting heavy loads, always make a special effort to ensure that the bottom of the sling legs are fastened to the load in a manner that will prevent damage to the load. To aid in lifting, many pieces of equipment have eyes fastened to them during the process of manufacture. With some loads, though, fastening a hook to the eye on one end of each sling leg provides an adequate means for securing the sling to the load.

It is important that protective pads be used when a fiber line or wire rope sling is exposed to sharp edges at the corners of a load. Pieces of wood or old rubber tires are excellent materials for use as padding.

Spreaders and Pallets

In hoisting with slings, the use of SPREADER BARS is often advisable to prevent crushing and damaging the load. Spreader bars are short bars or pipes which have eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load (fig. 11-45), the angle of the sling leg is changed and crushing of the load, particularly in the upper portion, is avoided.

The use of cargo PALLETS in combination with slings is a big advantage on jobs that involve the hoisting and moving of small lot items. (See fig. 11-46.) Spreader bars may also be needed frequently to avoid damaging the load when hoisting pallets. The pallet provides a small platform or board on which a number of items can be placed and moved as a unit rather than piece by piece. Palletizing obviously is quicker and easier than moving each individual item separately.

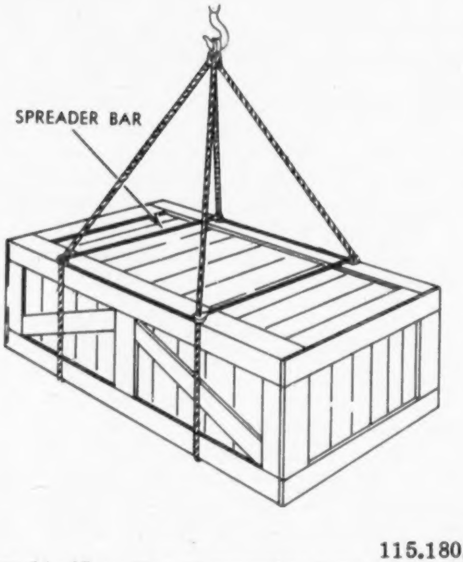

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Figure 11-45. — Use of spreader bars in sling.

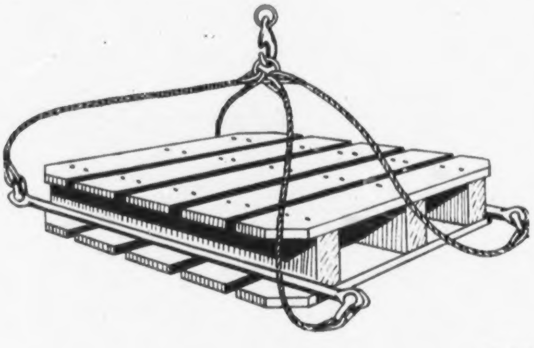

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Figure 11-46. — Pallet.

Frequently, packages of uniform size are palletized when shipping and remain in the original pallet until used. You may not enjoy the luxury of that many pallets in your work. Nevertheless, you will need several pallets for efficient operation. One can be loaded as a previously loaded pallet is being hoisted. After each pallet is unloaded, the hoisting crew returns it for reloading. One set of slings can handle a number of pallets.

When using slings, it is important to remember that the greater the angle from vertical, the greater will be the stress on the sling legs. This is graphically illustrated in figure 11-47.

Inspecting Wire Rope and Fiber Line Slings

Broken wires are a major defect to look for when inspecting wire rope slings. When 4 percent of the total number of wires in the wire rope are found to have breaks within the length of one lay, the sling is unsafe and should be removed from service immediately. Always make sure that any sling found to be deformed or damaged is also removed from service. Given proper care, a wire rope sling should render service for a long time.

Slings must be inspected frequently and removed from service when defects are disclosed showing that they are no longer safe. Bear in mind that a defective sling may cause serious injury to personnel and extensive damage to equipment in case of failure under load.

Fiber line slings should be checked carefully for signs of deterioration due to exposure to the weather. A close check should also be made to determine whether any of the fibers have been broken or cut by sharp-edged objects.

When inspecting slings, do not overlook the hooks. Examine hooks for cuts, cracks, or signs of distortion.

Using Chain Slings

Steel-length CHAIN SLINGS are available with variable type ends and lengths. One commonly used type is the 1/2-inch sling, obtainable in either 12- or 20-foot lengths.

Before doing any lifting with a chain sling, first place dunnage between the chain and the load to provide a gripping surface. For hoisting heavy metal objects with chain slings, always use chafing gear around the sharp corners on the load to protect the chain links from being cut. As chafing gear, use either planks or heavy fabric. In handling rails, or a number of lengths

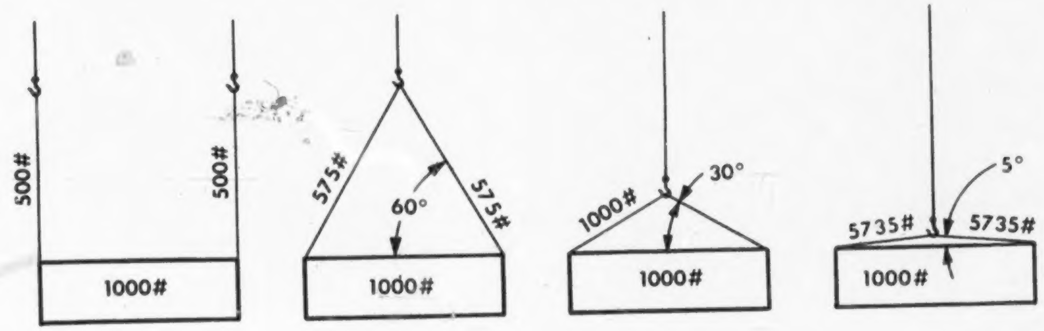

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Figure 11-47. — Stress on sling on various vertical angles.

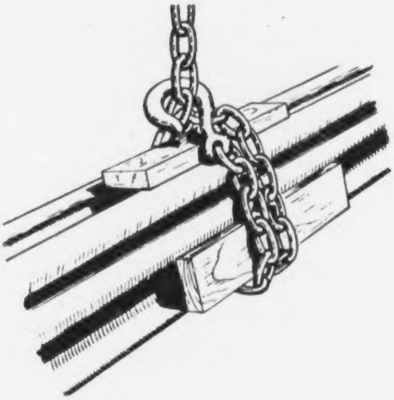

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Figure 11-48. — Chain sling.

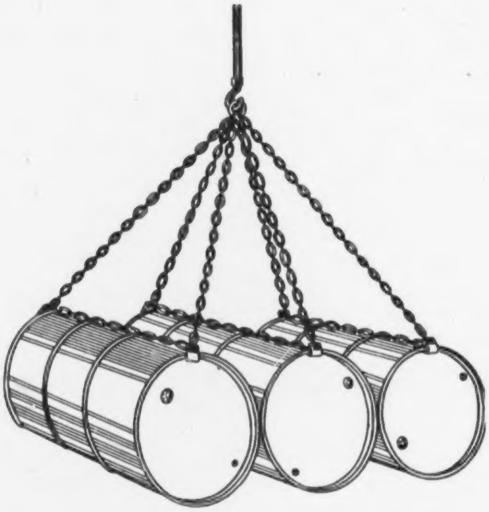

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Figure 11-50. — Drum-handling sling.

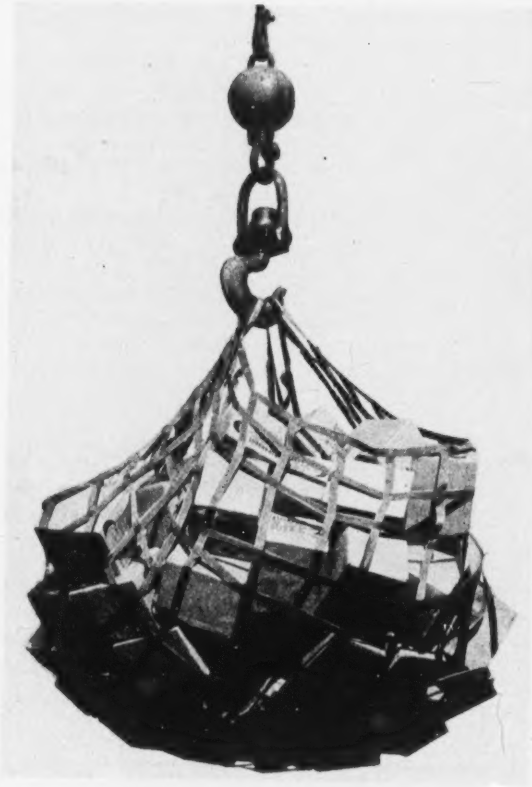

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Figure 11-49. — Cargo net in use.

of pipe, a round turn should be made and the hook placed around the chain. (See fig. 11-48.)

In using chain slings, care must be exercised to avoid twisting or kinking of the chain while under stress. This condition might cause failure of the chain, even in handling a light load. Before

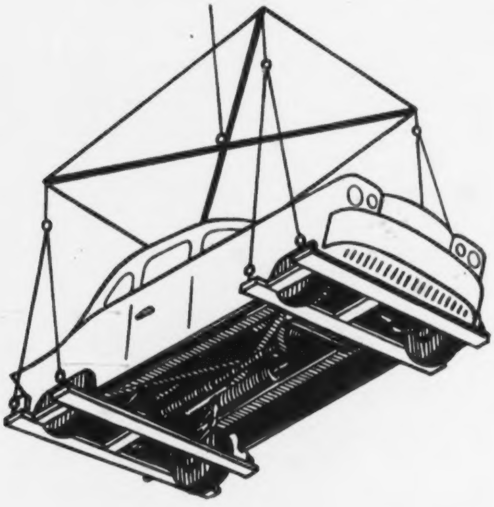

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Figure 11-51. — One type of vehicle sling.

lifting, therefore, make sure that the chain is free from twists and kinks. In addition, see that the load is properly seated in the hook (not on the point) and that the chain is free from nicks or other damage. Avoid sudden jerks in lifting and lowering the load, and always consider the angle of lift when using a sling chain bridle.

Store chains in a clean, dry place where they will not be exposed to the weather. Before storage, it is a good idea to apply a light coat of lubricant to prevent rust.

Makeshift repairs such as fastening links of a chain together with bolts or wire should never be permitted. When links become worn or damaged, cut them out of the chain; then fasten the two adjacent links together using a connecting link. After closing the connecting link, welding will make it as strong as the other links. For cutting small-size chain links, use bolt cutters. For cutting large-size links, use a hacksaw.

Inspection of Chain Slings

Inspection of chain slings is necessary to ensure that they are maintained in safe, operating condition. Obviously, a chain sling that is used continuously for heavy loading should be inspected frequently. It is a good idea, however, that seldom used slings be inspected at least once a month. Bear in mind that chain slings are less reliable than manila or wire rope slings because the links may crystallize and snap without warning.

In making an inspection, examine the chain closely link-by-link, looking for such defects as stretch, wear, distortion, cracks, nicks, and gouges. Under ordinary conditions, wear will be confined to the ends of the links where adjoining links rub together. If wear is detected, each link should be lifted and its cross section measured. Chains should be removed from service when any individual link shows wear greater than 25 percent of the thickness of the metal.

Any link that shows evidence of cracks, distortion, nicks, or cuts should be replaced. However, if a chain shows evidence of stretching or distortion of more than 5 percent in a 5-link section, make sure the entire chain is discarded and destroyed.

The least sign of binding at the juncture points of links indicates collapse in the sides of links, resulting from stretch. Such a condition is dangerous, and the chain should be removed from service.

Nets, Hooks, and Special Slings

Cargo nets are made of fiber line, wire rope, or nylon line. They are efficiently used for handling non-uniform packages. A loaded cargo net is shown in figure 11-49. Figure 11-50 through 11-51 illustrate other special types of slings and hooks in use.

CHAPTER 12

MOTOR GRADERS

The motor grader is a vitally important piece of construction equipment when it comes to the building of roads and airstrips. After the road or airstrip site has been cleared, stripped, cut and filled, and a rough grade established, the motor grader has the job of finishing to final grade.

The SEABEES use various makes and models of motorized graders. Some of the makes and models that you may encounter are the Galion, model 118; Caterpillar, model 12; Austin-Western, model Pacer 100; and Allis-Chalmers, model DD. It is beyond the scope of this manual to present information on all designs of graders.

General information on starting, operating, and maintaining motorized graders is given in this chapter. Also included is information on the capabilities and utilization of motor graders. In addition, Naval Construction Force hand signals are illustrated and information is provided on safety precautions to be observed when operating or working near motor graders.

PURPOSES AND USES OF MOTOR GRADERS

The motor grader is a rubber-tired, hydraulically operated, single-engine unit used to shape and finish material used in road and airstrip construction.

The single-engine provides power for all grader functions.

The action of the hydraulically operated control levers provides the means for moldboard, scarifier, and wheel control during grader operations.

The motor grader is equipped with a six-speed forward and a two-speed reverse constant mesh transmission, and a drive axle which allows the chain driven 4-wheel tandem drive to pivot when operating on rough terrain.

A motor grader's primary purpose is cutting and moving material with the blade for final SHAPING and FINISHING, rather than for digging and earthmoving. To a lesser extent, it is also used for blade-mixing of asphalt paving materials, ditching, snow removal, and scarifying (breaking up dense material).

PRINCIPAL PARTS

Figure 12-1 shows the principal parts of the Galion 118 motor grader. Broadly speaking, the rig consists of a grader mechanism and a prime mover. Some of the primary parts of the grader with which you should be familiar are discussed below.

The PRIME MOVER is that part of the grader referred to as a rubber-tired tractor. It is power driven by a 4- or 6-cylinder diesel engine and started by an electric starting motor. The prime mover has 4-wheel tandem drive.

The prime mover engine and the grader mechanism are supported by the FRAME, which extends the full length of the rig (see fig. 12-1). The blade, which consists of a cutting edge attached to a curved moldboard, is supported by two tiltable blade holding brackets.

The MOLDBOARD, with the blade attached, is considered the basic grader mechanism. The blade can be lifted, lowered, rotated, tipped forward and backward, tilted, shifted to one side or the other, and angled to the horizontal. By adjusting the hand rods the moldboard may be extended to the extreme left or right side of the grader for working back slopes.

The SCARIFIER is a set of teeth used to break up material too compact to be readily penetrated by the blade. The scarifier is pulled by two arms connected to the drawbar, which is pivoted on a ball-and-socket connection at the front of the frame.

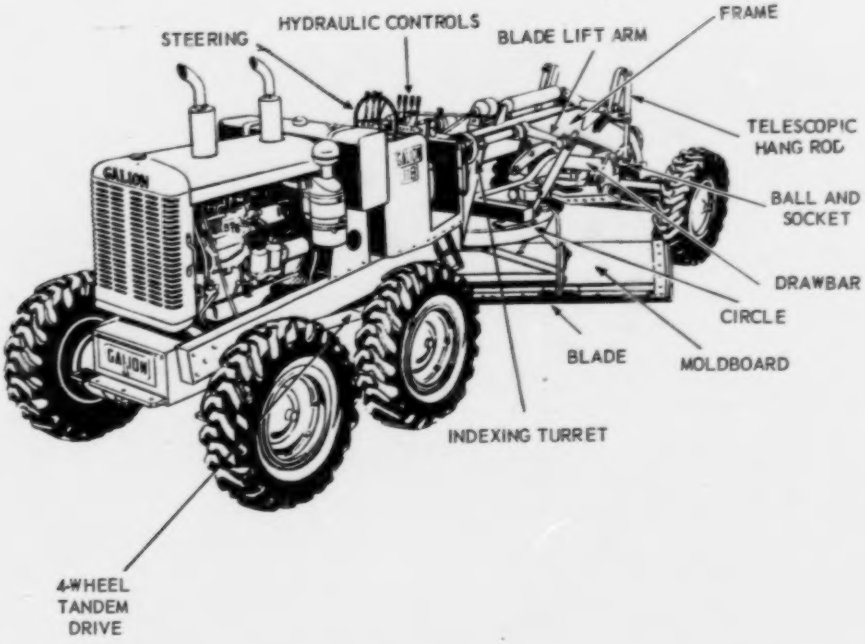

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Figure 12-1.—Principal parts of the Galion motor grader.

OPERATION OF MOTOR GRADERS

This section provides general information on prestart checks, starting and operating procedures, operation checks, and securing methods applicable to the Galion model 118 B grader. For detailed instructions on grader concerned.

PRESTART CHECKS

Prestart check and service made on motor graders are basically the same as those described for equipment in previous chapters of this manual except as indicated below.

Check the hydraulic oil level while the oil is cold and prior to starting the engine. The correct level is midway between low and high on the sight gage. The gage is located on the left outside panel of the operator's cab. Maintain oil at the indicated level, using only hydraulic oil specified by the manufacturer.

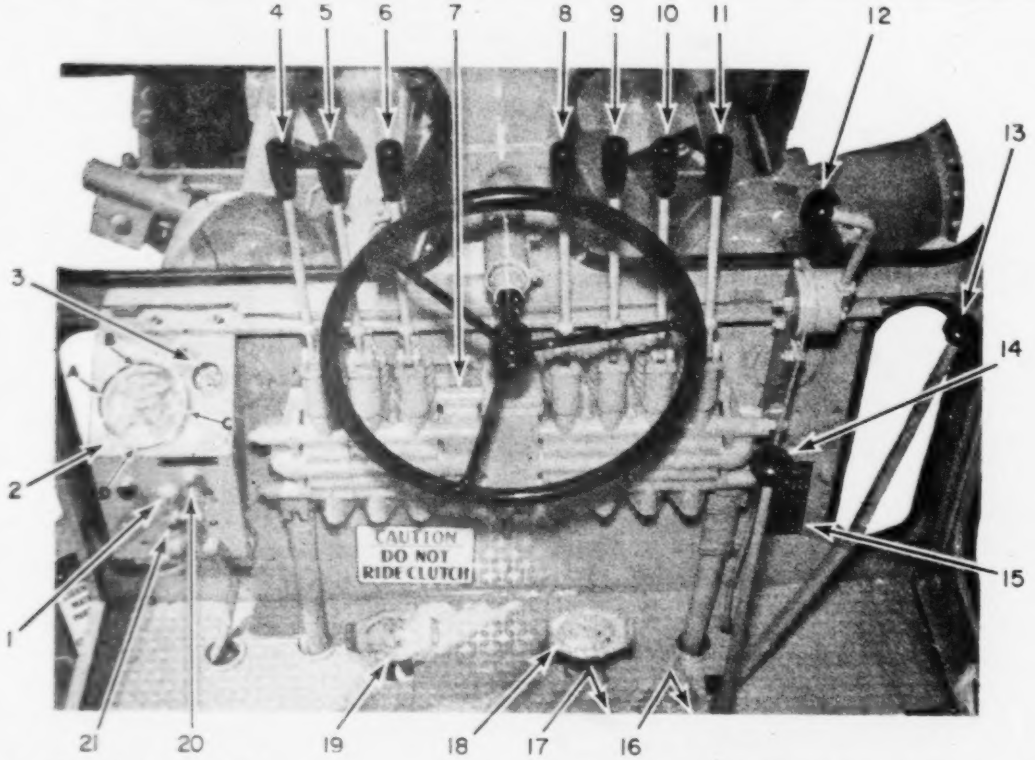
Drain the engine fuel filter and strainer daily of about one-fourth pint of fuel to remove dirt and water accumulation. Drain cocks are provided for this purpose. The fuel filter and strainer are located on the right side of the grader engine.

STARTING CHECKS

After starting the engine, but before putting the motor grader into operation, a few additional checks are necessary. These checks are basically the same as those discussed in previous chapters; therefore, information on starting checks need not be repeated here.

DURING OPERATION CHECKS

Malfunctions may be present even though all indicators on the motor grader register within the specified range during operation. There are various symptoms by which common types of malfunctions can be identified. These symptoms are the same as described in various portions of the manual for automotive vehicles, tractors and attachments, and cranes and attachments; therefore, the symptoms need not be repeated here.



1 KEY LOCK AND SWITCH
2 INSTRUMENT CLUSTER
  A. FUEL GAGE
  B ENGINE LUBE OIL PRESSURE
  C VOLTMETER
  D ENGINE COOLANT TEMPERATURE
3 OIL CLUTCH TEMPERATURE GAGE
4 LEFT MOLDBOARD CONTROL LEVER
5 SCARIFIER CONTROL LEVER (OPTIONAL)
6 CIRCLE REVERSE CONTROL LEVER
7 BLANK (SNOW PLOW OR BULLDOZER CONTROL)
8 HYDRAULIC SHIFTABLE MOLDBOARD CONTROL LEVER
9 CIRCLE SIDE SHIFT CONTROL LEVER
10. LEANING FRONT WHEEL CONTROL LEVER
11. RIGHT MOLDBOARD CONTROL LEVER
12 ENGINE SPEED CONTROL LEVER
13 RANGE SHIFT LEVER
14 GEAR SHIFT LEVER
15 GEAR SHIFT INSTRUCTION PLATE
16 PARKING BRAKE LEVER (NOT SHOWN)
17 ACCELERATOR PEDAL (NOT SHOWN)
18 SERVICE BRAKE PEDAL
19 CLUTCH PEDAL
20 TRANSMISSION STOP BRAKE PUSH SWITCH
21 LOW OIL PRESSURE BY-PASS PUSH SWITCH

115.481

Figure 12-2. — Indicators and controls, Galion model 118 motor grader.

OPERATING MOTOR GRADERS

The safe and efficient use of a motor grader requires skill and alertness on the part of the operator. To develop the skill required for safe and efficient grader operation, you should become familiar not only with its make-up, but also understand its capabilities and limitations.

Let's take a look at one particular model of motor grader to familiarize you with its instruments and controls, as well as operational capabilities. The information given is on the Galion model 118 motor grader, and applies ONLY to that machine. The Galion model 118 is one of several types of motor graders used by the SEABEES.

Figure 12-2 shows the location of indicators and controls on the Galion model 118. The purpose of various indicators and controls is explained below; the numbers in parentheses correspond to those used in figure 12-2 to indicate the location of individual indicators and controls.

The KEY LOCK AND SWITCH (1) is used to close the circuit and energize the engine starting motor.

The INSTRUMENT CLUSTER (2) contains the fuel supply gage (A), the engine lube oil pressure gage (B), the voltmeter (C), and the engine coolant temperature gage (D).

The OIL CLUTCH TEMPERATURE GAGE (3) indicates the operating temperature of the oil within the clutch independent oil system.

When the LEFT MOLDBOARD CONTROL LEVER (4) is pulled backward, the left side of the moldboard will raise; when the control lever is pushed forward, the left side of the moldboard will lower.

By pushing the SCARIFIER CONTROL LEVER (5) forward, the scarifier will lower; by pulling the control lever backwards, the scarifier will raise.

When the CIRCLE REVERSE CONTROL LEVER (6) is pushed forward, the circle reverse with the moldboard attached will rotate clockwise; when the control lever is pulled backward, the circle reverse with the moldboard attached will rotate counterclockwise.

The moldboard shifts to the right of the machine when the HYDRAULIC SHIFTABLE MOLDBOARD CONTROL LEVER (8) is pushed forward, and shifts to the left of the machine when the control lever is pulled backward.

By pushing forward on the CIRCLE SIDE SHIFT CONTROL LEVER (9), the circle reverse with the moldboard attached can be positioned to the right of the machine for bank sloping; and when pulled backward, the circle reverse with the moldboard attached can be positioned to the left of the machine for bank sloping.

The front wheels of the grader will lean to the right when the LEANING FRONT WHEEL CONTROL LEVER (10) is pushed forward, and to the left when the control lever is pulled backward.

By pulling the RIGHT MOLDBOARD CONTROL LEVER (11) backward, the right side of the moldboard will raise; by pushing forward on this lever, the moldboard will lower.

The ENGINE SPEED CONTROL LEVER (12) is pulled backward in increase engine speed and pushed forward to decrease engine speed.

The RANGE SHIFT LEVER (13) is used to select either HIGH or LOW range in conjunction with the gear speeds. By placing the lever in the forward position, the high range is selected; by placing the lever in the backward position, the low range is selected.

The GEAR SHIFT LEVER (14) is used to select the desired transmission gear ratio to provide 6 speeds forward and 2 speeds in reverse.

The PARKING BRAKE LEVER (not shown) is located to the left of the operator's seat. When the lever is pulled up the parking brakes are applied; when the lever is pushed down to the horizontal position, the brakes are released.

The ACCELERATOR PEDAL (not shown) is used to vary engine speed, thus allowing easier gear shifting, close blading, and driving the machine over long distances and through traffic.

The SERVICE BRAKE PEDAL (18) is used to stop the grader by hydraulically applying the grader tandem drive wheel brakes.

When application of the power-actuated clutch shaft stop-brake is desired, press the CLUTCH PEDAL (19) to the floorboard and press the TRANSMISSION STOP BRAKE PUSH SWITCH (20) on the instrument panel. The clutch brake will be applied and the gear or range and direction of the grader can be made.

The LOW OIL PRESSURE BY-PASS PUSH SWITCH (21) must be depressed at the same time the key switch is turned to the cranking position when starting the grader engine to bypass the lubricating oil low pressure shutdown mechanism. Continue to depress this switch until the engine lubricating oil reaches operating pressure, then release.

Starting The Engine

In starting the Galion model 118 motor grader under normal conditions, follow the step-by-step procedure given below.

(1) Depress clutch pedal and place the transmission in neutral.

(2) Move the engine speed control to the halfway position and depress the accelerator pedal.

(3) Depress the low oil pressure by-pass push switch and turn the key switch to the cranking position.

(4) When the engine starts, release key switch and it will return to the run position.

(5) When the lubricating oil reaches operating pressure, release the by-pass switch.

If the engine fails to run, do not attempt to re-start until the cranking motor has come to rest. To do so could result in damage to the cranking motor and/or engine flywheel ring gear.

Steps For Operating

Observe the following operating steps for placing the Galion model 118 motor grader in motion after the engine is started:

(1) Set the engine speed control at load speed.
(2) Disengage the engine clutch by depressing the footoperated clutch pedal.
(3) Position the gear shift lever in the desired speed range.
(4) Position range shift lever in the desired position.
(5) Release the parking brake.
(6) Engage the engine clutch by releasing the clutch pedal, and gradually release the foot accelerator increasing the speed of the engine.
(7) Shift the gear shift lever into the proper speed ranges as the grader moves forward.

Stopping The Motor Grader

When bringing the motor grader to a stop, proceed as follows:

(1) Decrease engine speed by depressing the foot accelerator pedal.
(2) Apply pressure to the footbrake pedal.
(3) Disengage the engine foot clutch.
(4) Shift the gear shift lever to neutral.
(5) Shift the range shift lever to neutral.
(6) Engage the grader parking brake.

Stopping The Grader Engine

To stop the motor grader engine, here are the steps to follow:

(1) With no load on the engine, allow the engine to idle 3 to 5 minutes before shutting down. This permits the engine to cool down and provides gradual and uniform cooling of engine parts.
(2) Turn the key switch counterclockwise to the OFF position.

HAND SIGNALS

Hand signals used in grader operations are depicted in appendix I. It is important that you not only recognize and understand these hand signals, but also be able to give them when called upon to act as a signalman.

SECURING

When securing a motor grader, position the moldboard so that it is inboard of the wheel tracks for traveling, drive the grader to the designated securing area, and position it in a safe manner. After the grader has come to a stop, lower the moldboard to the ground, set the handbrake, position the gear shift lever to neutral, position the speed range lever to neutral, place the engine speed control in the shutoff position, and turn the key switch counterclockwise to the OFF position. Secure your seat cushion by tipping it forward so that, if it rains, the water will run off. Do not turn your cushion over.

TECHNIQUES OF GRADER OPERATION

Although the motor grader can do a variety of jobs—and do them well—it is a machine whose performance depends largely upon the skill of the operator.

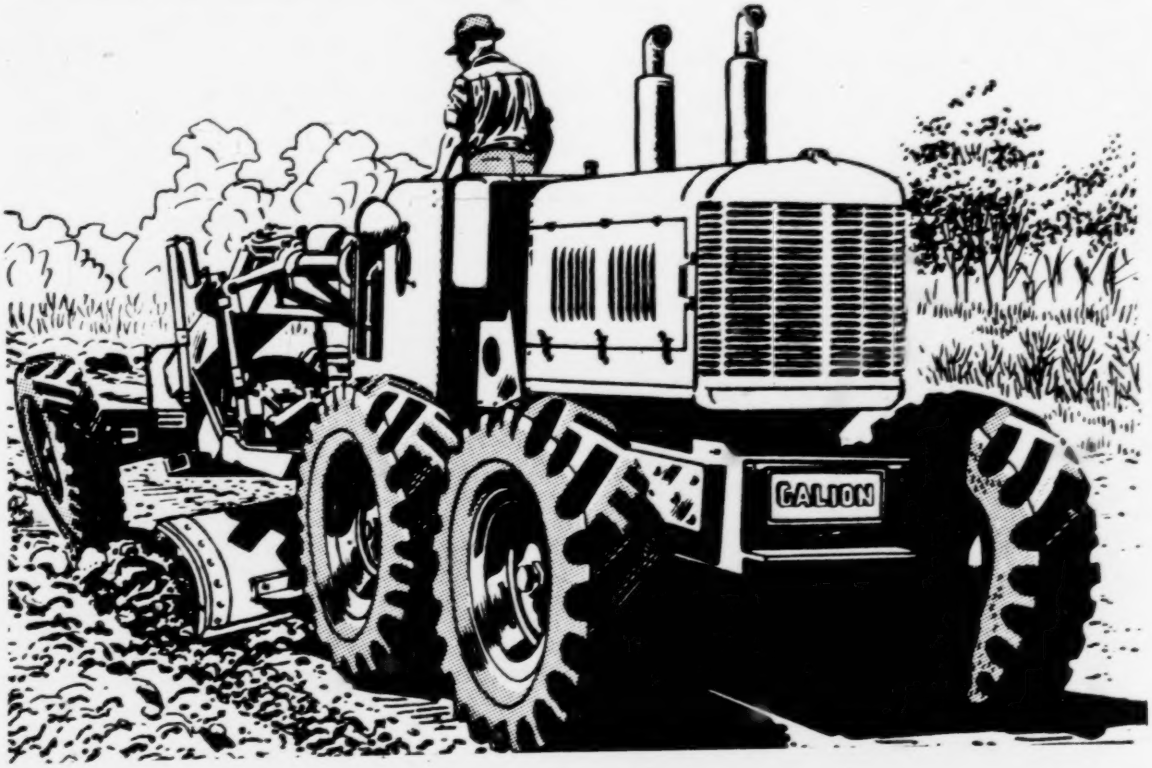
The grader works most efficiently when moving ahead grading or leveling. Proper use of the front wheels is a great aid in both steering and grading operations. Lean the top of the wheels in the direction you are moving the material. For instance, if the moldboard is extended to the right side of the machine in moving a heavy cut or windrow to the left, as shown in figure 12-3, a pulling force to the right is exerted on the front end of the machine; thus the top of the wheels should be leaned to the left to counteract this pulling force.

When the grader itself is working on the sloping side of a ditch, lean the top of the front wheels enough to keep them in a vertical working position (see fig. 12-4); this will help keep the grader from drifting down the slope.

On high bank-cutting operations, as illustrated in figure 12-5, lean the top of the wheels toward the bank. This keeps the blade properly positioned for the bank sloping.

When jobs are confined to short stretches or narrow widths, changing the blade from forward to reverse grading position (see fig. 12-6) requires a circle reverse movement of only about 70 degrees. Operators usually make cutting passes in reverse, then move the windrow over on the forward trips, thus saving valuable time and speeding operations by eliminating frequent turning around of the grader.

For reverse blading, be sure the scarifier hang rods are shortened and the scarifier teeth removed. The blade is then set so that the



115.292X

Figure 12-3. — Wheel lean.

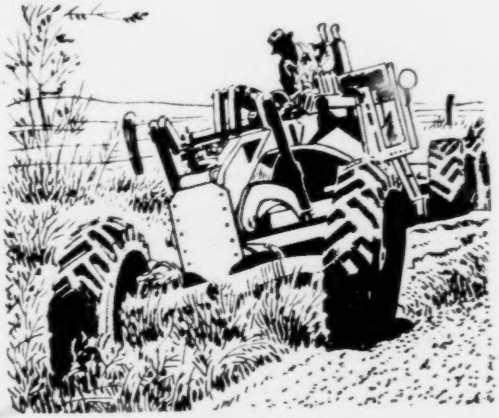


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Figure 12-4. — Working sloping ditch with wheel lean.

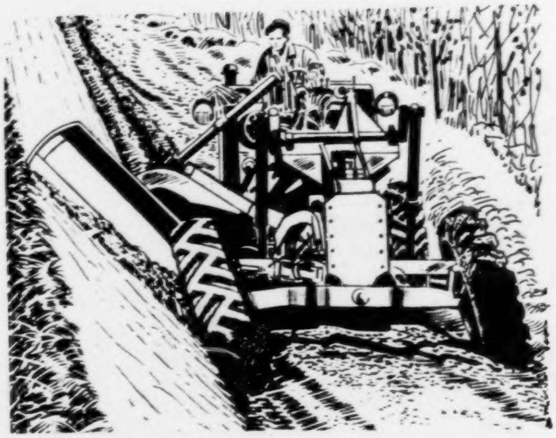

Figure 12-5. — High bank-cutting operation with wheel lean. 115.294X

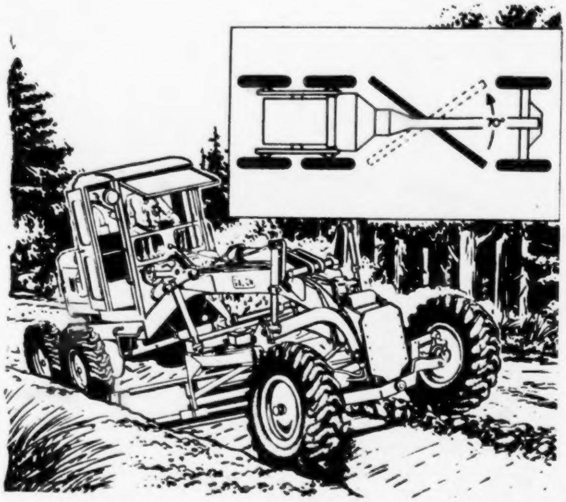

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Figure 12-6. — Changing blade from forward to reverse.

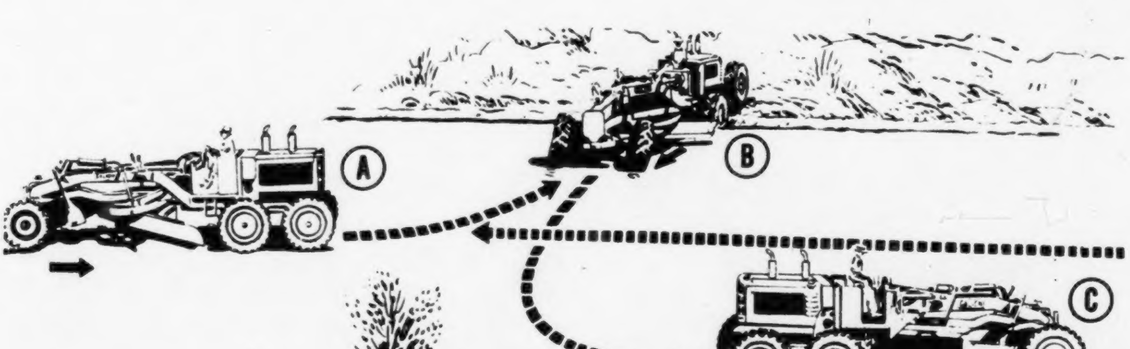
toe (leading end of blade) is just outside the rear tires and the heel (trailing end of blade) discharges outside the left front tire. In all reverse work, leaning wheels are handled the same as in forward work.

When a motor grader makes a number of passes over a distance of less than a 1,000 feet, it is normally more efficient to back the grader the entire distance to the starting point than to turn around and continue working from the far end. But if your passes cover a distance of 1,000 feet or more, it then is more efficient to turn your grader around and start blading from the far end to the starting point.

A roadway wide enough to permit turning around without backing would be easiest for turning a grader. The combined maneuvering advantages of leaning wheels and tandem drive are a big help in turning the machine around on either a roadway or runway. Figure 12-7 illustrates a simple procedure to follow in turning the grader around. With the wheels leaned in the direction of the turn (A), back across the ditch (B), and then complete the turn (C). You will find that if you leave the wheels on grade and lean in the direction of the turn, the grader will make the turn with ease. Always BACK ACROSS the ditch, and LEAVE the front wheels on the roadway or runway.

When working around curves, always lean the top of the front wheels in the direction of the turn, as shown in figure 12-8.

To be a good operator, a knowledge of blade positions is necessary. All controls, as illustrated in figure 12-2, are within easy reach — either in the sitting or standing position — and you always have a good view of the work you are doing. The blade and circle are mounted on a drawbar, which is connected to the front of the frame by a ball-and-socket joint, as shown in



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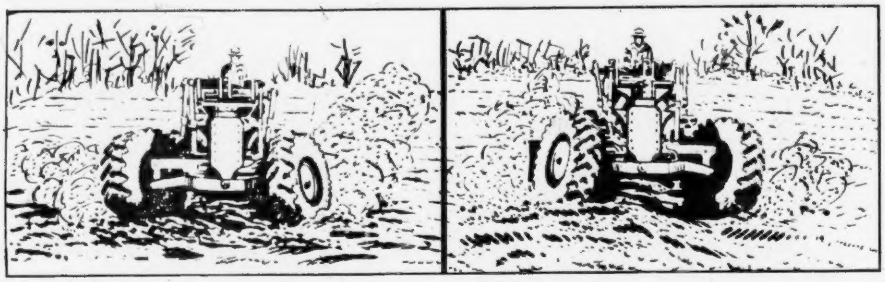
Figuer 12-7. — Turning the grader around.

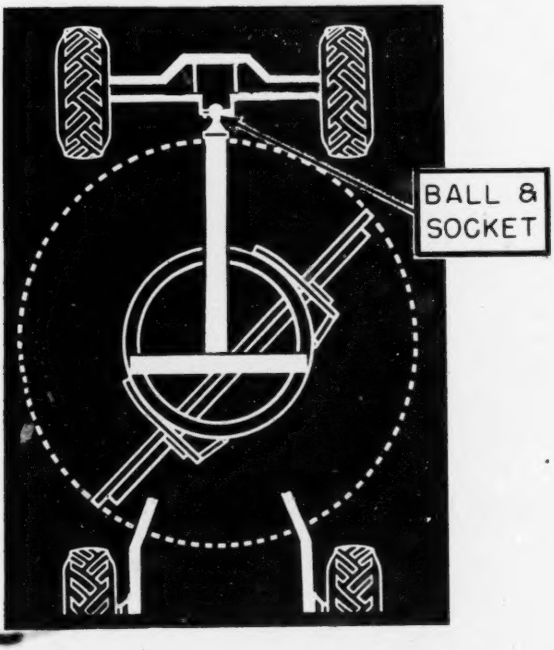


115.296X

Figure 12-8.—Leaning wheels in direction of turn.

figure 12-9. The blade is, therefore, free to move into any workable position. Up-and-down movement is controlled by the BLADE LIFT levers, which are most often used simultaneously when making up-and-down blade movements.

Effective use of the basic blade positions shown in figure 12-10 is necessary to achieve a high level of skill in operating techniques. Practice will help you to realize how easily blade control can be accomplished.



115.297X

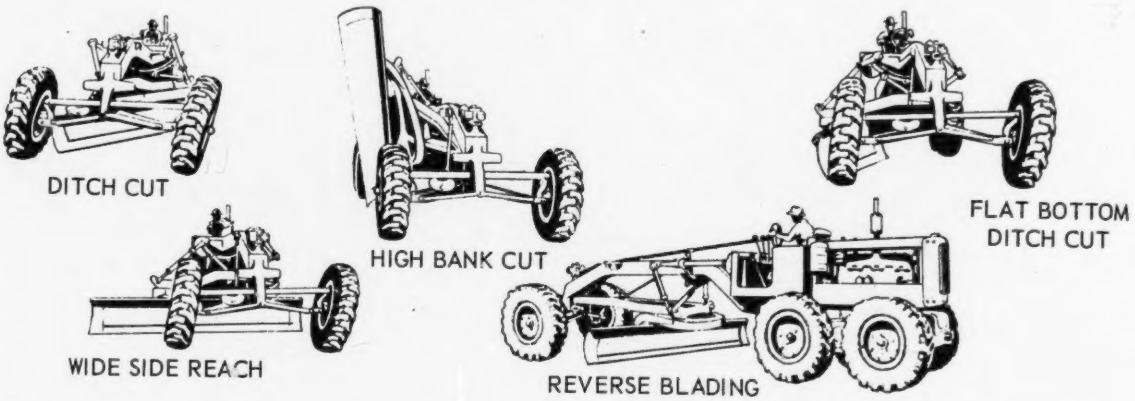
Figure 12-9.—Ball-and-socket connection.

Proper moldboard pitch adjustment also is important to good grader performance. In figure 12-11, observe the four moldboard pitch adjustments (views A, B, C, and D); also observe the insert in figure 12-11 which shows the means by which these adjustments are obtained; For normal grading operations, use the upright position on the moldboard as shown in view (A). For greater cutting action, use the backward pitch on the moldboard as shown in view (B). For greater mixing and rolling action on the material being moved, use a slight forward pitch on the moldboard as shown in view (C). When spreading or maintaining surface material, use a greater forward pitch on the moldboard as shown in view (D). This pitch accomplishes a partial compaction of the surface materials and assures filling the low spots.

There are many factors involved in the selection of blade pitch; such as, type of operation, kind of material, depth of cut, speed of operation, etc. You should experiment with different pitch positions for best results.

When scarifying becomes necessary on a roadway or runway, the scarifier control lever is engaged for the movement of the scarifier attachment. On all grading work, be sure that the scarifier block is lowered to the point where there is not interference between the grader drawbar and the scarifier block.

The scarifier contains a total of 11 teeth, which measure 47 inches in width from outside tooth to outside tooth. Therefore, if you have a 24-foot roadway, you will have to make approximately seven passes to scarify the complete width of the roadway.



115.144X

Figure 12-10.– Normal grader blade positions.

When using a grader to correct corrugated roads, extreme care must be exercised so that the condition will be corrected rather than made worse. Deep cuts on a washboard surface will set up blade "chatter" which emphasizes, rather than corrects, the corrugations. Scarifying may be required if the surface is too badly corrugated. When extremely hard or consolidated material requires scarifying, it is recommended that alternate scarifier teeth be removed (see fig. 12-12); this will facilitate passage of the scarifier through the material. Scarifying should always

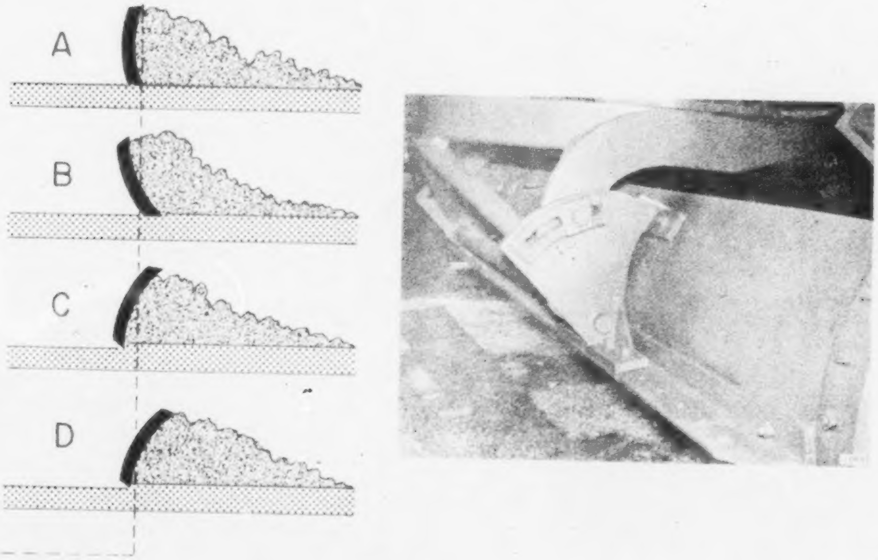


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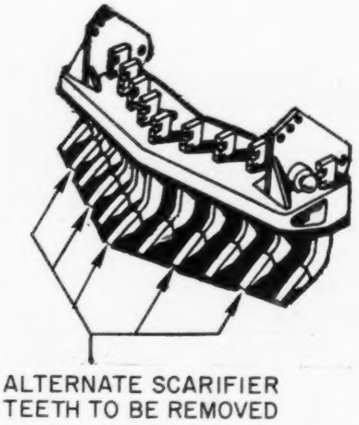
Figure 12-11.—Moldboard pitch adjustments.



115.299
Figure 12-12. — Scarifier teeth removal.

be done, however, with a minimum of six teeth; operating with fewer teeth may damage the scarifer or grader. NEVER make sharp turns with scarifier teeth in the ground. This will damage the scarifier and possibly break off the teeth. Scarifier teeth can be adjusted up and down or removed entirely, depending upon the condition of the material or blade positioning.

With proper moisture content, the surface can be leveled by cutting across the corrugations. Alternate the blade so that the cutting edge will not follow the rough surface. Cut the surface to the bottom of the corrugations and reshape the road surface by spreading the windrows in an even layer across the road.

One of the tests of a good grader operator is the ability to cut a straight ditch line. Make sure the ditch line stakes are set according to the plans. The marking cut, as shown in figure 12-13, is a light cut, usually 3 to 4 inches deep. This makes it easy to hold the machine straight and to follow the ditch stakes accurately on succeeding heavier cuts.

For efficient ditching, the moldboard should be positioned at about a 45-degree angle from the zero-degree angle, as shown in figure 12-14, with the toe (leading edge) of the blade directly behind the front wheel. It may be necessary to remove the scarifier teeth to keep them from interfering with the blade. The blade should be angled enough to make the desired cut, with the heel of the blade raised enough to form the windrow either inside or outside the rear wheels (see fig. 12-15). Remember to lean the

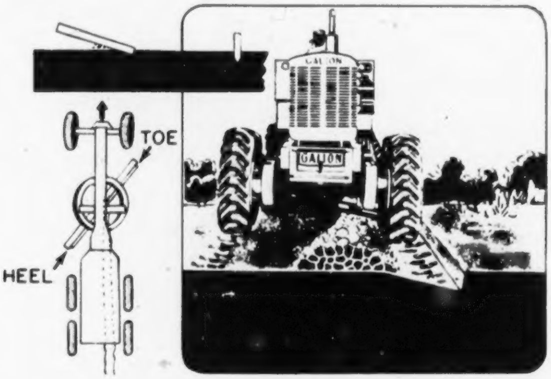
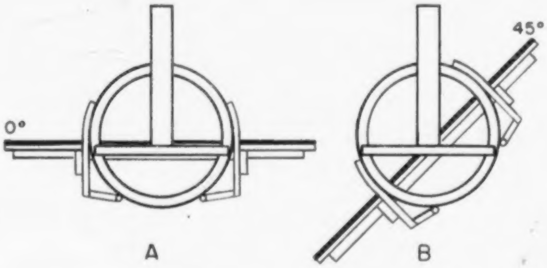


Figure 12-13. — Marking cut. 115.300X



(A) Blade in zero degree angle.
(B) Blade in 45° degree angle.

Figure 12-14. — Positioning moldboard. 115.301X

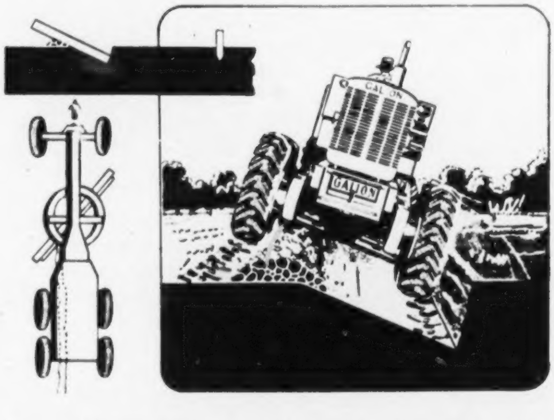
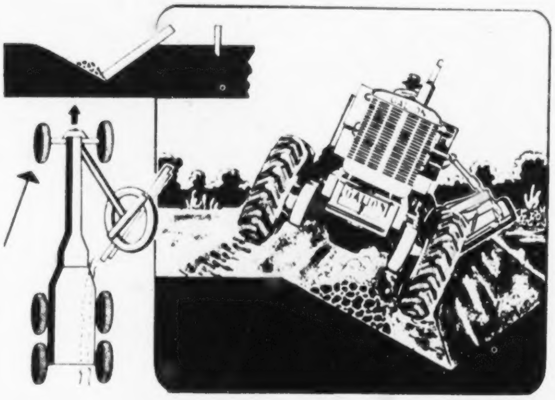
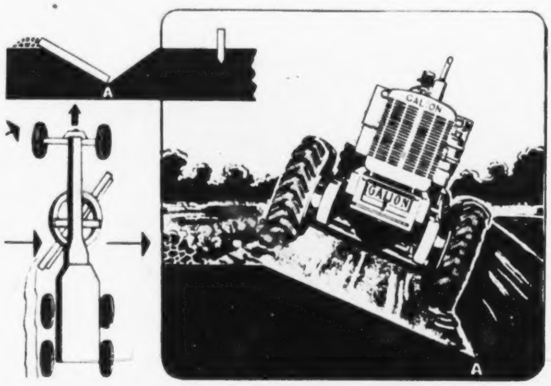


Figure 12-15. — Additional pass. 115.302X



115.303X
Figure 12-16. — Bank sloping.



115.304X
Figure 12-17. — Finishing the inside slope.

top of the front wheels in the direction you are moving the material. After the initial ditch line cut, make all remaining cuts count to the utmost. Apply as much pressure to the toe of the blade as the grader will smoothly handle in the most efficient gear.

After each heavy cut the material should be windrowed or spread toward the middle of the road — away from the ditching operation. Don't reduce traction efficiency and make uneven cuts by trying to operate over the soft, loose windrows of previous cuts. You will save time in the end by keeping all material from previous cuts well out of the way.

After the ditch is made, the bank should be given a sloping cut. Position the circle and blade with the heel resting at the bottom of the slope, so that the material flows inside the right rear tandem wheels, as shown in figure 12-16. The toe of the blade should be forward toward the right front tire. The tops of the wheels should be leaned toward the bank (this is an exception to the usual rule).

If the ditch is to have a plain "V" bottom, you now take a finishing pass on the inside slope, as shown in figure 12-17, to remove the material from the bank sloping operation.

If a flatbottom ditch is required, proceed as follows:

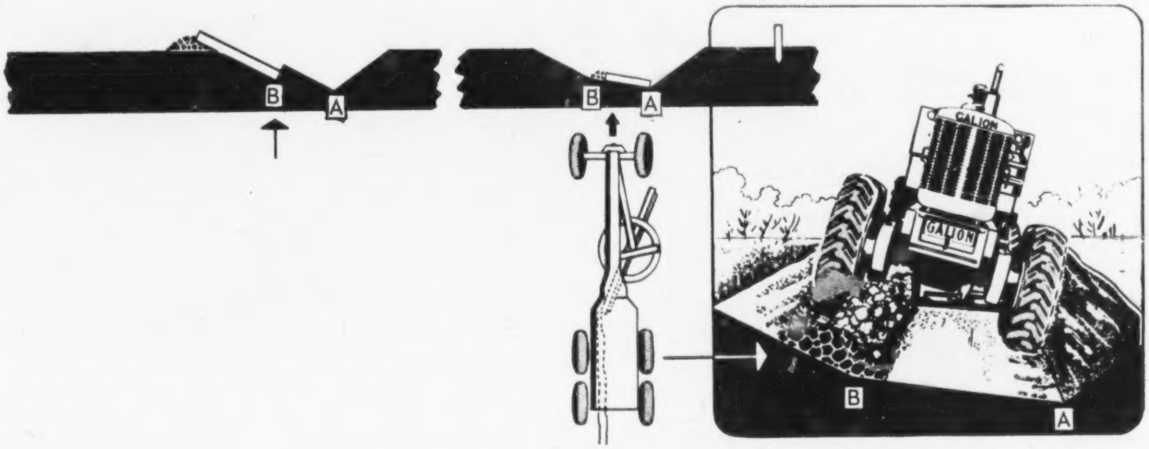
First cut another "V" ditch on the inside slope, as indicated at (B), figure 12-18. The blade should be positioned to move the material out to the top of the road.

Next, make a flat cut in the bottom of the ditch. For this operation the complete length of the blade is placed in the ditch, with the toe of the blade at the base of the bank slope and the heel at the base of the inside slope. This operation moves the dirt to the inside slope.

Now make one or two final passes, as required, on the inside slope to move the dirt up onto the road and outside the rear wheels. The shoulder is then finished, with any remaining material being windrowed or spread toward the center of the road, as illustrated in figure 12-19.

The final step in road grading is usually the building up of a CROWN, or downward sloping from the centerline of the road toward the shoulders. The purpose of the crown is to provide drainage from the centerline toward the shoulders and ditch.

For crowning, the blade is tilted to conform to the specified angle of the crown, and the material is side cast in windrows from the shoulders of the road up toward the centerline. The first pass is made down one shoulder. If the length of the pass warrants, turn around and proceed on the opposite shoulder, with the tilt and blade angle in relatively the same position. However, if the distance is too short, back up and start on the opposite shoulder, with opposite tilt and blade angle. By repeated overlapping passes made in this manner, two windrows are worked up from the shoulders to the centerline, where they are combined into one. This windrow is then knocked off with the blade set at zero degrees (at a right angle

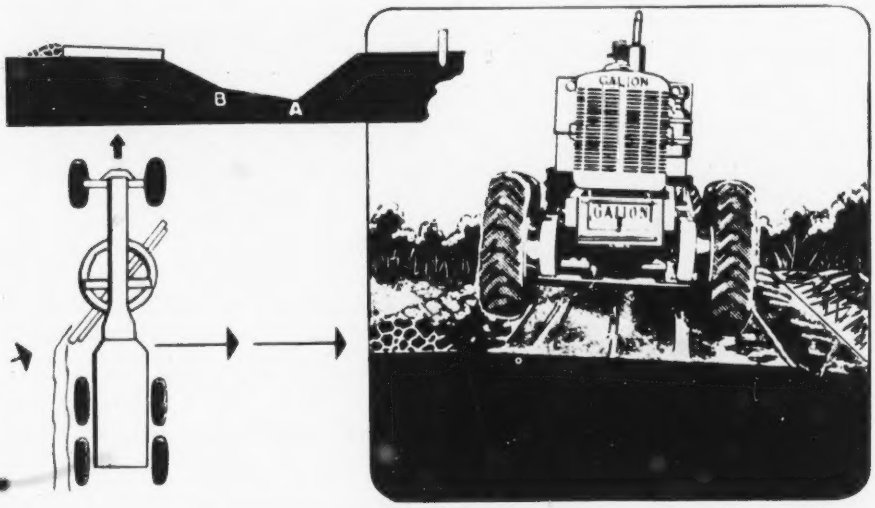


115.146X

Figure 12-18.—Cutting the flatbottom.

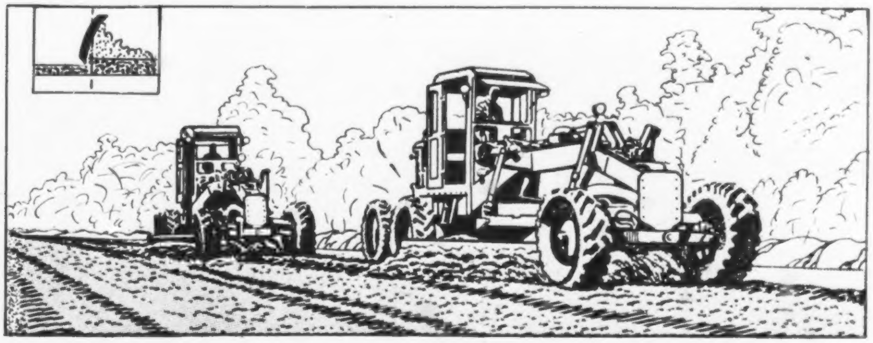
to the fore-and-aft axis of the rig). Any spill around the ends is windrowed back to the shoulders, thus finishing the crown.

Blading the various types of mix used as road surfaces is a very important motor grader function in regards to road maintenance. When blading oil mix, a medium speed (such as third gear) should be used. The moldboard should be pitched slightly forward and angled at about 30 degrees, as indicated in figure 12-20. This position should give the widest possible spread with maximum mixing action. In mixing with the grader, the windrow is moved from side to side by successive cuts with the blade. Several graders



115.305X

Figure 12-19.—Moving windrow from shoulder.



115.306X

Figure 12-20. — Blading oil mix.

can operate, one behind another, on the same windrow. If the mixture is wetted by rain, mixing continues until the mixture is dry. After mixing, the material is again bladed into a windrow prior to spreading. During mixing, additional bitumen can be applied to any lean sections which appear. All particles of the completed mix should be coated and uniform in color.

Operations are performed as rapidly as possible, consistent with the skill of the operator and the condition of the surface being maintained.

Operation in each gear is at full throttle. If less speed is required, a lower gear should be used. Normally, if the grader is operated too fast, it will have a tendency to bounce, thereby giving the surface a washboard appearance, which will require additional time and passes. Make sure you are aware of this problem. If washboarding is not corrected, it will create unnecessary wear and tear on the other construction equipment utilizing the haul road or work area. Table 12-1 lists the speeds normally used in various grader operations.

You can increase the efficiency of an operation by grading in reverse when distances are long and turning impracticable. Remember: this type of operation is for operators who have developed high grader skills.

A work output formula which may be used to prepare preliminary estimates of the total time in hours required to complete a grader operation is:

$$\text{Total time} = \frac{P \times D}{S \times E}$$

The number of passes (P) depends upon the operation.

The distance (D) traveled in each pass is expressed in miles.

Speed (S) is expressed in miles per hour. It is the most difficult factor in the formula to estimate. As work progresses, conditions may require that the speed estimates be increased or decreased. The work output is computed for each operation which is performed at a different rate of speed. The sum of the values obtained in each part is the total time required for the operation. Care must be taken to use the correct number of passes for each speed used.

The grader efficiency (E) factor takes into account the fact that a 60-minute work hour rarely is attached. Efficiency varies, depending

Table 12-1. — Approximate Speed Ranges Used in Various Grader Operations

OPERATION	SPEED (MPH)	OPERATION	SPEED (MPH)
MAINTENANCE	3 TO 10	BANK SLOPING	2
SPREADING	3 TO 6	SNOW REMOVAL	10 TO 15*
MIXING	5 TO 15		
DITCHING	2 TO 3	FINISHING	3 TO 5

*EXCEPTION TO MAXIMUM SPEED PERMISSABLE ON HIGH TYPE RUNWAYS AND HIGHWAYS.

143.195

upon supervision, operator skill, maintenance requirements, and site conditions. A value of 60 percent is average. It must be verified or adjusted on each job.

An example problem: Five miles of gravel road are to be leveled and reshaped, using a motorized grader with a 12-foot moldboard. Six passes are estimated as required to complete leveling and reshaping. The type of material permits passes 1 and 2 in second gear at 2.8 mph, passes 3 and 4 in third gear at 3.4 mph, and passes 5 and 6 in fourth gear at 5.4 mph. Using an efficiency factor of 60 percent, how long will it take to complete the job?

Substituting in work-output formula:

$$\text{Total time} = \frac{2 \times 5}{2.8 \times 0.6} + \frac{2 \times 5}{3.4 \times 0.6} + \frac{2 \times 5}{5.4 \times 0.6} =$$

$$6.0 + 4.9 + 3.1 = 14 \text{ hours.}$$

OPERATOR'S MAINTENANCE

Every Equipment Operator is required to perform certain daily maintenance services on the motor grader he is operating as a matter of routine. This maintenance includes the required inspection service, lubrication, and adjustments which will maintain the grader in a safe operating condition, prevent malfunctions, and avoid or delay the need for major repairs.

The procedures used in an operator's maintenance inspection of the various components of motor graders are similar to those described in previous portions of this manual for vehicles, materials-handling equipment, and tractors, and need not be repeated here.

You can assure proper maintenance by following guidelines set forth in the manufacturer's lubrication charts and service manuals.

MOTOR GRADER SAFETY

A number of major safety precautions applicable to motor graders are listed below for your guidance.

Caution should be used when dressing back slopes since the stability of the grader is greatly reduced with the weight of the circle and blade hanging on one side. In such cases, speed should be reduced.

Speed must be reduced before making a turn or applying the brakes. Some graders have 2-wheel brakes, others have 4-wheel brakes.

The grader must be kept in gear when going downhill.

When moving the grader from one jobsite to another, place the moldborad in a position so that it is inboard of the wheel tracks.

Always lower the blade to the ground when securing or working on the machine.

Bring the grader to a complete stop before shifting from a forward gear to reverse gear, or from a reverse gear to a forward gear.

Before moving the grader, make a "walk-around" inspection to observe the physical condition of the machine.

CHAPTER 13

SCRAPERS

Scrapers are large earthmoving machines capable of loading, hauling, dumping, and spreading material. You will find scrapers especially useful on large earthmoving jobs, such as airfield construction, and road projects built in rolling terrain involving many cuts and fills. They have the capability to make shallow cuts while loading, transport large loads for a considerable distance at a relatively high rate of speed, and spread material in a thin, uniform layer.

Scrapers are efficient when operated in light to medium soils which are relatively free of roots, stumps, and boulders. Heavy or consolidated soils require the supplemental use of tractor-drawn rippers and pusher tractors to assist in obtaining maximum loads. In rough terrain, cuts are opened with dozers before scraper operations are started. Fine, dry sand is difficult to load because it will not pile up in the bowl of the scraper. Wet clay and similar soils are sticky and difficult to eject from the scraper. Most scrapers are built with open tops which make them suitable for loading by clamshell, shovel, conveyor, or front-end loaders.

General instructions on starting, operating, and maintaining scrapers are given in this chapter. Information is presented on the capabilities, optimum working distance, and utilization of scrapers. In addition, Naval Construction Force hand signals are illustrated and information is provided on safety precautions to be observed when operating or working near scrapers.

TYPES AND USES OF SCRAPERS

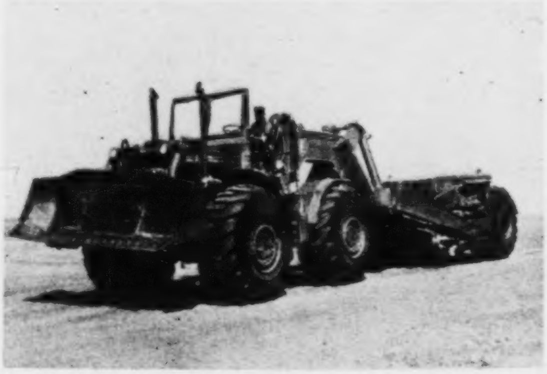
Scrapers used by the Navy are especially designed to ensure the performance of earthwork functions under varied conditions.

There are two general types of scrapers: the towed scraper and the self-propelled scraper. The TOWED SCRAPER is a 4-wheel rig which is towed by a hitched-on prime mover as shown in figure 9-8. The SELF-PROPELLED SCRAPER is a 2-wheel rig which is attached to a rubber-tired prime mover. The prime mover may be a 4-wheel tractor as shown in figure 13-1, or a 2-wheel tractor as shown in figure 13-2. On both the towed and self-propelled scrapers, the scraper mechanism, exclusive of the prime mover, is identical.

TOWED SCRAPER

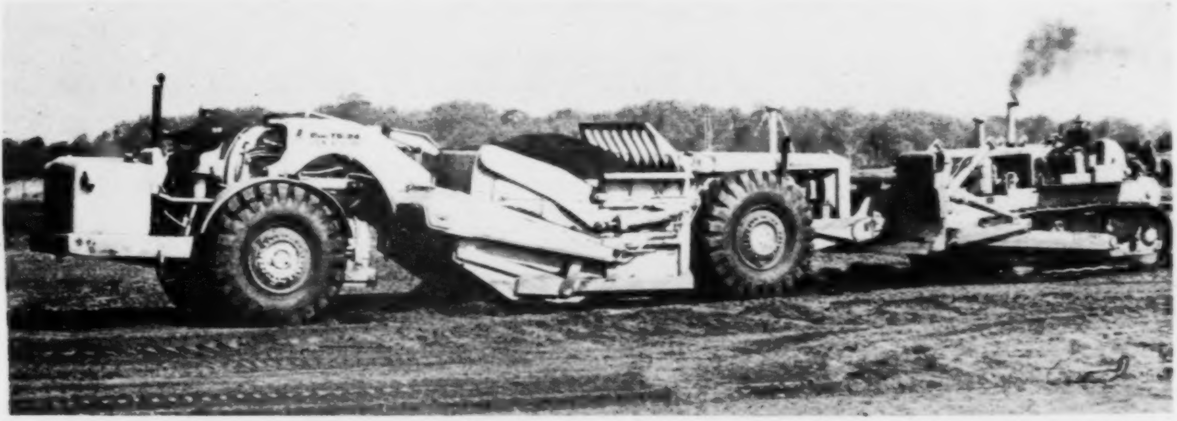
A nonmotorized scraper may be towed either by a wheeled or a crawler tractor. When the pulling tractor lacks power to load the towed scraper fully and quickly, a pusher tractor is used to assist. The crawler tractor is normally used for towing when large loads must be moved at rather slow speed because of steep grades, poor haul routes, or poor ground conditions.

Scrapers towed by crawler tractors are used for short to medium hauls ranging up to 1,500 feet. When moving materials less than 300 feet, it is normally more efficient to use dozers. On hauls greater than 1,500 feet, motorized scrapers



29.63(115F)B

Figure 13-1. — Self-propelled scraper.



29.63

Figure 13-2. — Self-propelled 2-wheel scraper with twin engine drive and pusher-tractor.

and/or power shovels, or front-end loaders are used in conjunction with other hauling equipment such as dump trucks, truck-off highway, or trailer dumps which will give better results. The haul-length efficiency of construction equipment will vary with the type of material, site condition, haul roads, and operator proficiency.

SELF-PROPELLED SCRAPER

Self-propelled scrapers generally have the same operational characteristics and capabilities as towed scrapers, but they are much more dependent on pusher-tractor for power when loading.

Scrapers drawn by rubber-tired tractors are employed when maximum use can be made of tractor speed. This combination requires good hauling conditions including grades, surfaces, and hauling distances from 900 to 5,000 feet in which to develop high average rates of speed.

CAPABILITIES AND UTILIZATION

Great yardage quantities are possible with scrapers. Although pusher tractors are required to supplement tractive power where large heaped loads are involved, the speed and capacity of scrapers fully compensate for the use of the pusher tractor in long range operations.

Scrapers are used for earthwork extending over considerable areas involving cut and fill in successive layers. Maximum production can be obtained if the scraper can haul a load goining and returning, thus eliminating time that would otherwise be lost in returning empty.

The time, distance, and capacity performance factors of various sizes of self-propelled scrapers are given in table 13-1.

Suppose you are operating a self-propelled, 18 cubic yard scraper. It will carry about a 23-cubic-yard heaped load. If the haul distance is approximately 1,500 feet, you can see by referring to table 13-1 that the scraper will haul 110 cubic yards of excavated materials per hour. However, when the hauling distance is only 400 feet, the scraper's capacity will increase to 220 cubic yards per hour.

PRIME MOVER — ADDITIONAL CONTROLS FOR SCRAPER OPERATION

When using the International Harvester TD-20B series crawler tractor as the prime mover for towing the M.R.S. model scrapers, the prime mover must be equipped with a DIVERTER VALVE CONTROL LEVER (see fig. 13-3). This lever actuates either the blade circuit when you push the lever away from you, or the scraper circuit when you pull the lever toward you.

After the diverter control lever is actuated in the scraper position, you will be able to operate the scraper from the tractor. The EJECTOR GATE LEVER (A), APRON CONTROL LEVER (B), and BOWL LEVER (C) (see fig. 13-4) are used to operate the scraper.

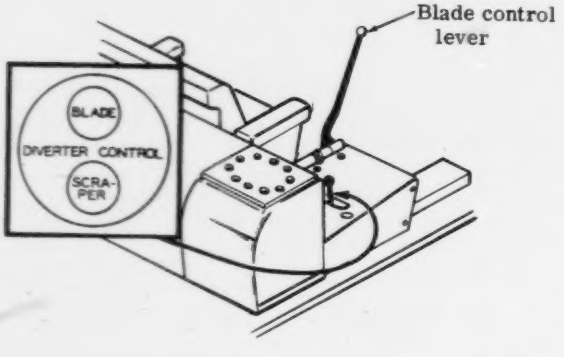
Table 13-1. — Self-Propelled Scraper Performance Factors

Heaped Capacity in Cu. Yd.	Length of Economical Haul in Ft. One Way	Cu. Yd. Per Hour of Excavated Quantities
3 to 4	100 to 400	60-42 to 75-50
6 to 8	200 to 600	110-74 to 130-82
11 to 15	300 to 800	130-82 to 150-96
18 to 23	400 to 1500	180-70 to 220-110
30 to 40	600 to 3000	235-80 to 280-100

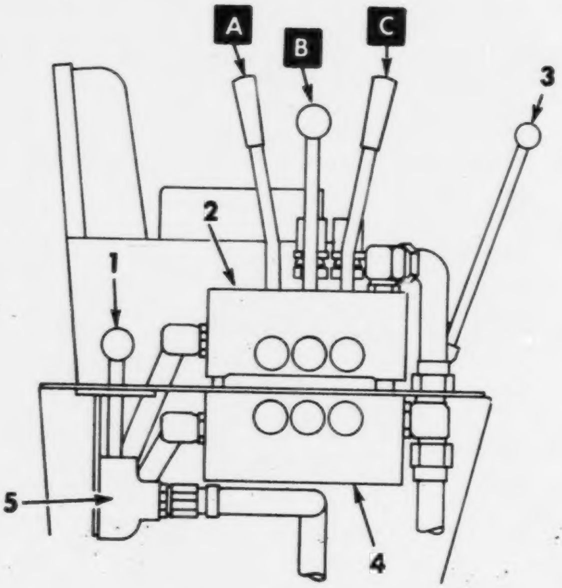
115.482

To unload the scraper, pull lever (B) towards you and hold it in this position until the apron reaches the desired height. Release lever (B) which will then return automatically to HOLD, allowing the apron to remain in the desired position. Then pull lever (A) towards you and hold it in this position until the ejector gate has moved all the way forward unloading the material. When the material has been ejected move lever (A) away from you to return the ejector gate to the rear of the bowl. Continue to hold the lever in this position until the ejector gate is moved all the way back; then release the lever. The lever will return automatically to the HOLD position.

To control the apron, push lever (B) away from you and hold it in this position until the apron has been lowered; release the lever and the lever will automatically return to HOLD. If you have completely lowered the apron, be sure to place the lever in FLOAT. To do this, push the lever all the way back. A detent within the control valve keeps the apron closed while the scraper is in operation. A slight effort against the lever engages this detent. A slight pull disengages the detent. The lever will then return to HOLD automatically.

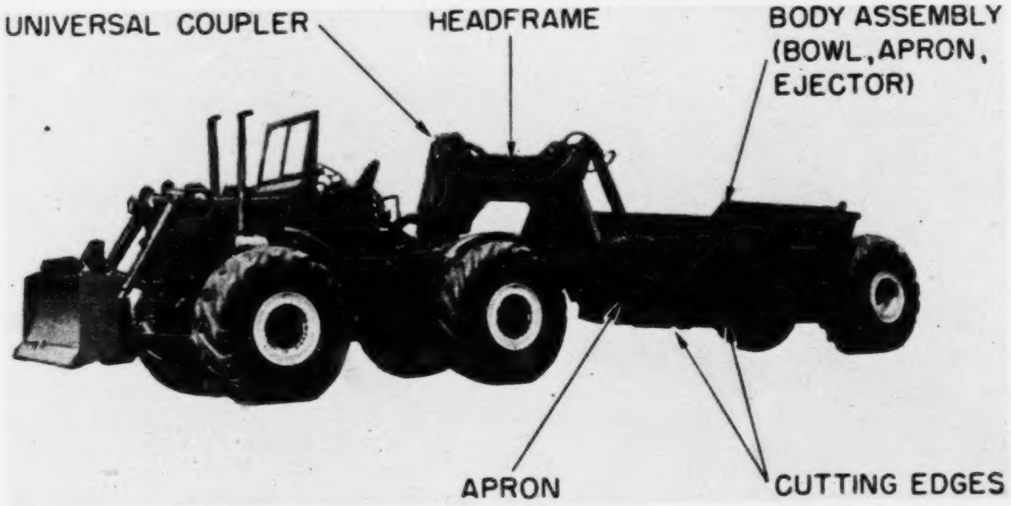


115.308
Figure 13-3. — Diverter valve control lever.



1. Diverter control valve lever.
2. Scraper control valve.
3. Blade control valve lever.
4. Dozer control valve.
5. Diverter control valve.

115.309
Figure 13-4. — Scraper control valves and controls.



29.63(115F)C
Figure 13-5.—Model S-110 scraper, 2-wheel or semitrailer mounted with M-R-S model I-110 tractor.

One point to remember when getting ready to operate the scraper bowl is: lower the apron completely and position the apron lever in FLOAT before placing the bowl lever in the RAISE position.

To raise the scraper bowl, pull control lever (C) toward you and hold it in this position until the bowl reaches the desired height. When released, the lever automatically returns to HOLD. With the lever in the hold position, the bowl remains at the selected height. To lower the bowl, push the lever away from you and hold it in this position until the bowl reaches the desired cutting position. The lever returns automatically to HOLD when it is released.

MODEL S-110 SCRAPER

The Model S-110 earthmoving scraper is a hydraulically-operated, 2-wheel (convertible to four-wheel), towed unit capable of loading, hauling, dumping and spreading up to 17 cubic yards of earth. It consists essentially of a body (with apron, ejector, and rear frame) and a head frame assembly (yoke). The leading portion of the gooseneck is equipped for attaching to a matching universal coupler provided on a rubber-tired tractor or on a 2-wheel dolly.

As a 4-wheel unit, the scraper is towed and operated by a crawler or wheeled tractor equipped with the necessary hydraulic system and controls, and capable of attaining 24,000 pounds of drawbar pull. The wheeled tractor must be capable of delivering 12 cfm of air at 80 to 105 psi for operation of the scraper brakes.

Increased capability is attained through the use of a rear-mounted push block which permits auxiliary pushing to obtain maximum payload. Increased versatility is attained through separate positive hydraulic control of the three main functioning components: bowl, apron, and ejector. This model scraper is equipped with rear wheel air-over-hydraulic brakes.

The 2-wheel scraper, as shown in figure 13-5, is designed to operate in conjunction with the M-R-S Model I-110 (MS), 4-wheel drive tractor (previously discussed). However, the scraper can be operated in conjunction with other tractors of similar power which are equipped with a universal coupler, suitable hydraulic equipment, and airbrake connections.

The 4-wheel scraper shown in figure 13-6 is designed to operate in conjunction with a crawler-type tractor equipped with suitable hydraulic equipment and capable of developing 24,000 pounds drawbar pull.

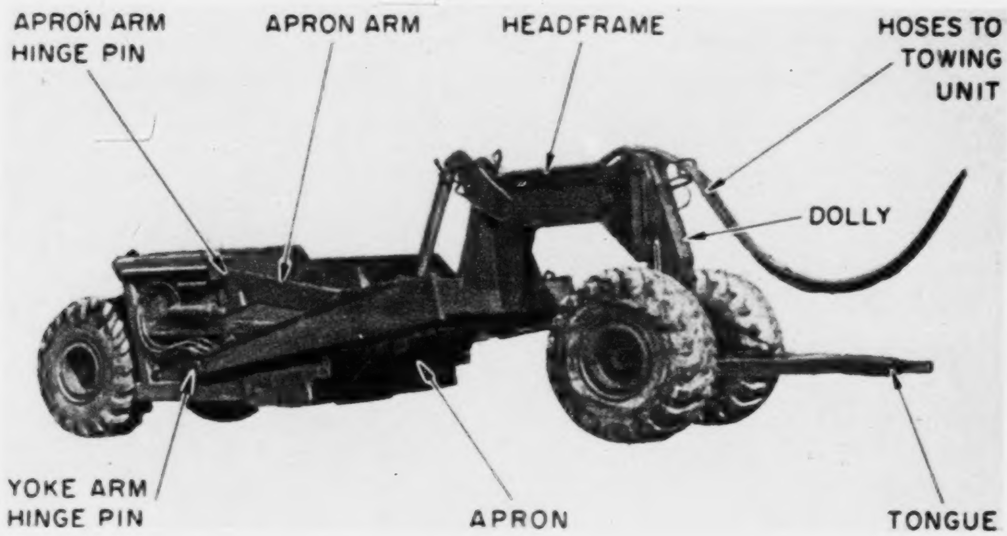


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Figure 13-6.—Model S-110 scraper with D-110 dolly converted for 4-wheel operation.

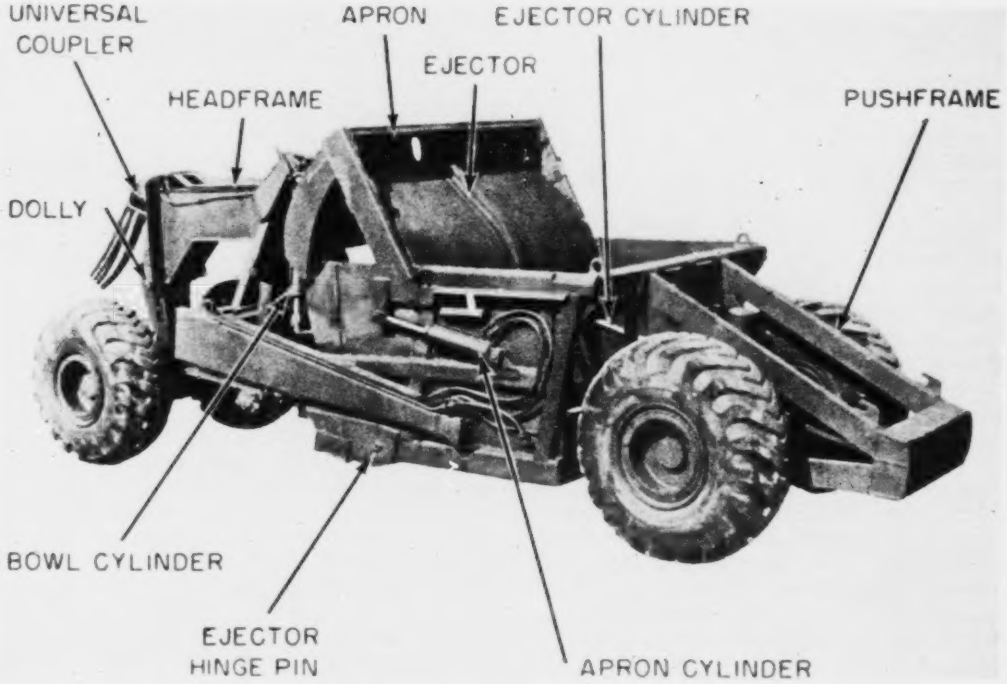
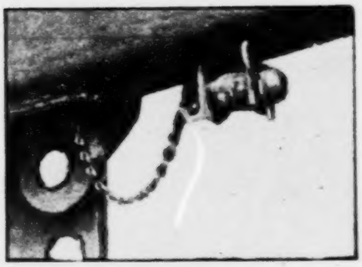
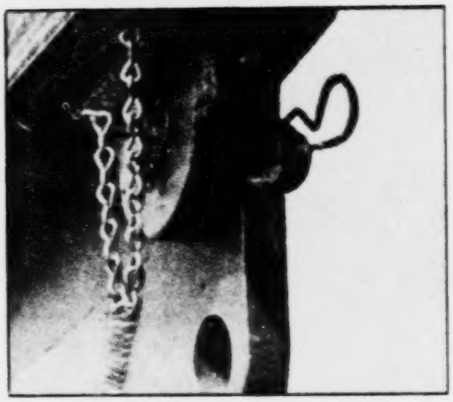


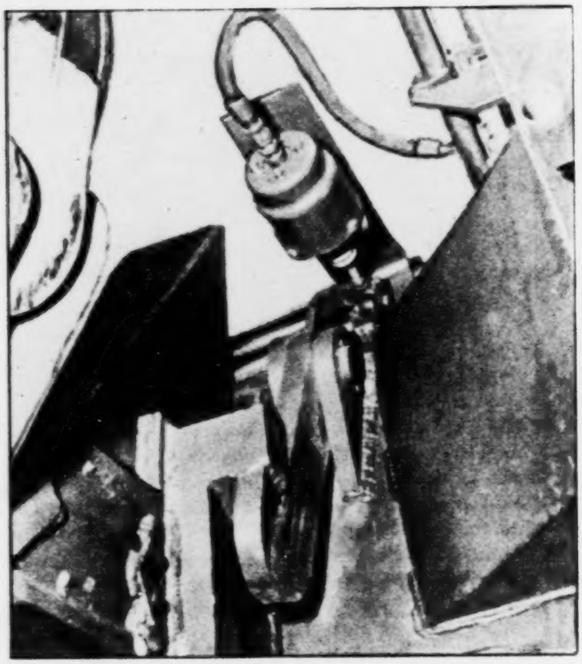
Figure 13-7.- Model S-110 scraper, overall view, dump position. 29.63(115F)E



Stowed



Travel
View A. Bowl Travel Lock Pins
(one on each side)



View B. Air Actuated Bowl Safety Lock
(one on each side)

115.313

Figure 13-8.—Scraper bowl locks.

Major Components

The major components of the Model S-110 scraper are shown in figure 13-7. The operator must become familiar with each component, its function, and relation to other components. Components of the scraper body work in combination with each other to perform the various operations of the equipment.

The bowl (fig. 13-7) is hinged to the yoke arms by two pins. It is raised and lowered by two hydraulic cylinders connected between the bowl and the gooseneck. Travel locks are provided which hold the bowl in travel position when not in operation. Each lock consists of two pins between the yoke arms and the bowl (view A, fig. 13-8).

Air-actuated bowl safety locks (view B, fig. 13-8) are provided to prevent accidental lowering of the bowl while in transit. The safety locks are actuated by two rotochambers mounted on the inside of the yoke arms and controlled by an air valve mounted on the main hydraulic valve control bracket on the M-R-S I-110 tractor. The bowl incorporates the cutting edges (figure 13-9).

The apron (fig. 13-7) is operated by two hydraulic cylinders—one on each side of the bowl. Movement of the apron controls the opening between cutting edges of the bowl bottom edge of the apron. This opening permits loading or dumping. When the apron is closed, it retains the load.

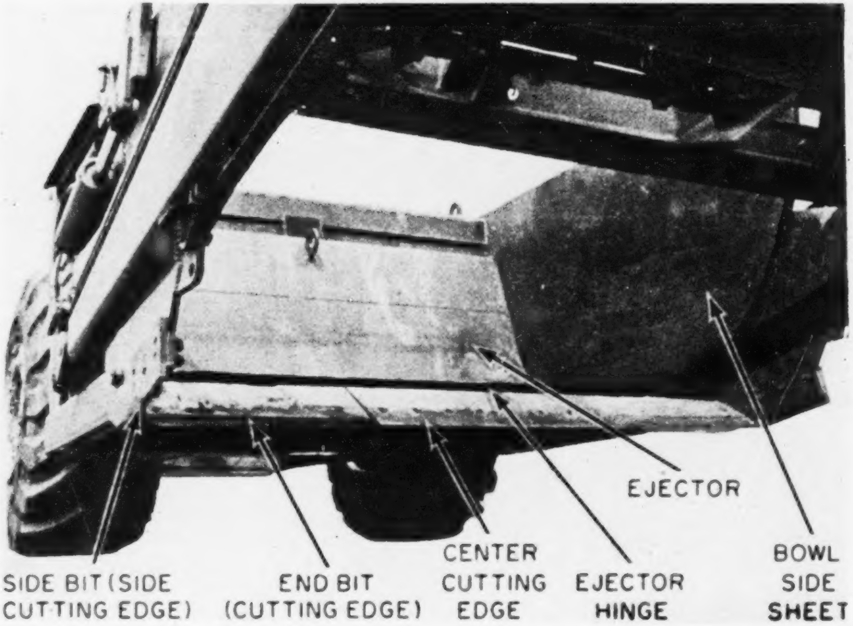


Figure 13-9.—Interior view of body of scraper. 115.314

The ejector (fig. 13-7) is hinged to the blade base in the bowl and forms the bowl bottom which carries most of the load. The ejector is controlled by a hydraulic cylinder (fig. 13-10) anchored to the center of the push frame. The cylinder piston rod is connected to the upper end of the ejector lever (fig. 13-11). The lower end of the ejector lever is pinned to the rear bowl frame. When the ejector cylinder piston rod is extended, the ejector lever is pushing forward, pivoting on its lower pin. Rollers are attached to the upper end of the ejector lever and run against a rail welded along the rear contour of the ejector. When the ejector lever moves forward, it forces the ejector up and forward on its hinge. When the cylinder piston rod retracts, the ejector lever is pulled rearward lowering the ejector.

The rear frame includes a push block which extends behind the rear wheels and furnishes an anchor for the ejector roll-out hydraulic cylinder (fig. 13-7).

The headframe (fig. 13-7) is hinged to the bowl and is connected to the front of the bowl

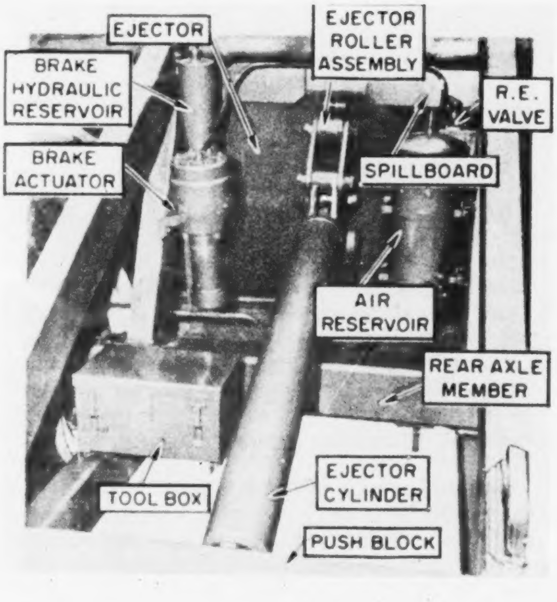


Figure 13-10.—Ejector mechanism in down position. 115.315

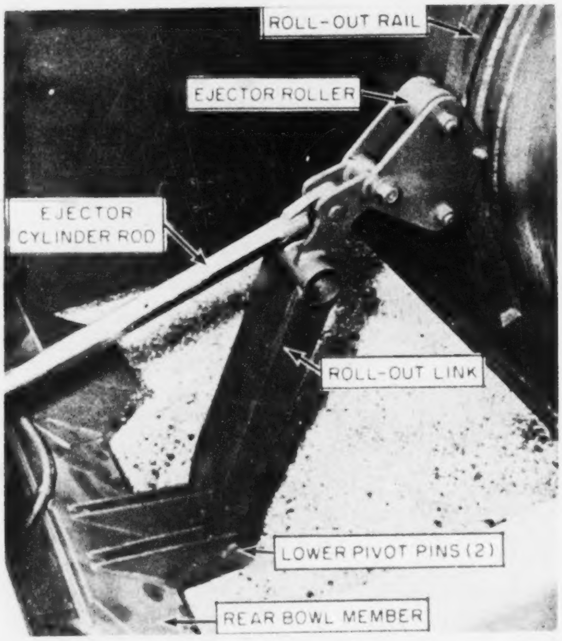


Figure 13-11.—Ejector mechanism in up (dump) position. 115.316

by two hydraulic cylinders. When these hydraulic cylinders are retracted, the bowl is raised to give maximum ground clearance. As these cylinders are extended, the cutting edge is lowered to the ground. When the scraper is moving, further extension of cylinders lowers the bowl and allows the cutting edge to dig at the desired depth. The hydraulic and air connections are mounted on the headframe. (See fig. 13-12.)

The front dolly (fig. 13-7) is attached to the headframe with a universal coupler, similar to the coupler on the I-110 tractor. It is free to turn and to oscillate on the spherical joint.

A drawbar tongue is welded to the front axle. A clevis at the opposite end of the tongue attaches to the tractor drawbar.

Hydraulic System

The power medium for operation of scraper components is hydraulic pressure. The scraper contains no hydraulic reservoir or pump and must obtain required amounts of hydraulic fluid at the proper flow from the prime mover. The prime mover pump delivers oil through connecting lines to the scraper hydraulic system (fig. 13-13). The hydraulic system consists of three circuits. One circuit controls the bowl lift cylinders: another circuit controls the apron cylinders; and the remaining circuit controls the ejector (or dump) cylinder. All controls are located on the tractor.

Air-Over-Hydraulic Brake System

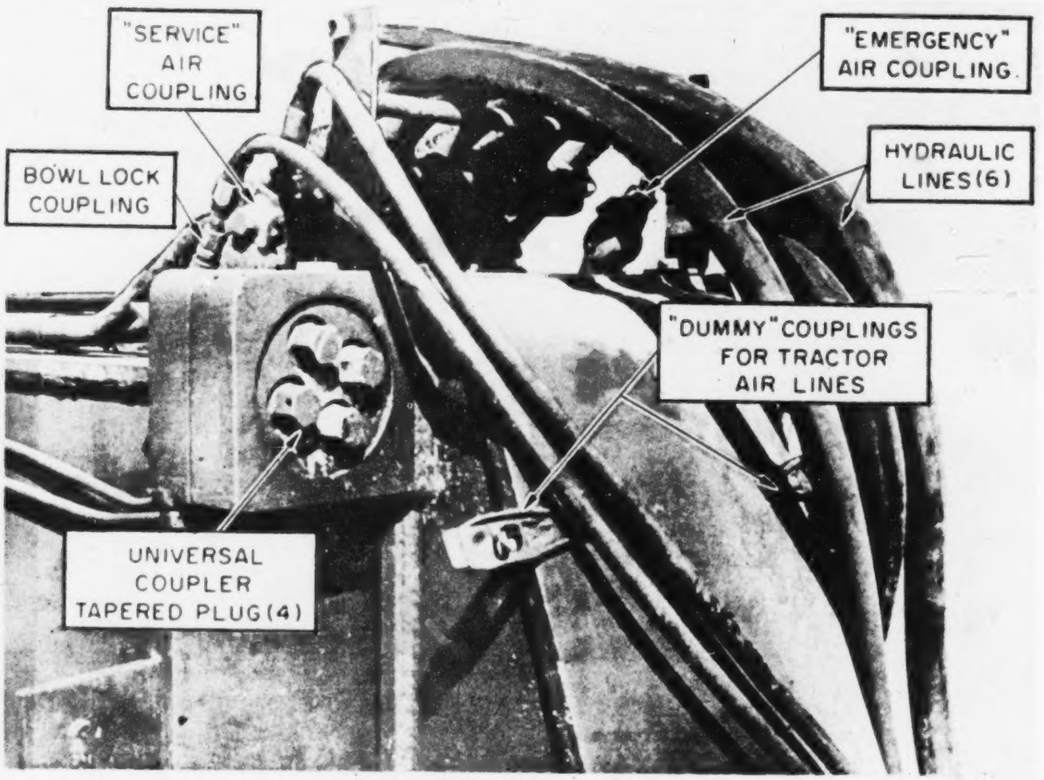
The scraper's airbrake system (fig. 13-14) incorporates an EMERGENCY air line and SERVICE air line which must be connected to the tractor air system to be operational. (The airhoses are not used if the towing tractor is a crawler unit.) Both lines are connected to the relay-emergency valve. An air supply reservoir is also connected to the relay-emergency valve, as shown in figure 13-15. When the trailer brakes are applied (by either the trailer brake control lever or the brake pedal on the tractor), the impulse of air from the tractor air system triggers the relay valve and allows air pressure from the supply reservoir to enter the brake rotochamber, thus applying the scraper brakes. The brake mechanism in each rear wheel is actuated by hydraulic oil forced into an expansion tube by the master cylinder. When the brake control on the tractor is returned to RELEASE position, the relay-emergency valve shuts off air to the exhaust from the brake rotochamber, thus releasing the scraper brakes. See fig. 15 pg 348

Air from the tractor air system is supplied to the scraper air reservoir through the EMERGENCY air line. Anytime this line is disconnected from the tractor air supply, the emergency valve immediately performs two operations: (1) it shuts off the air inlet port to prevent air escaping from the scraper reservoir, and (2) it applies the scraper's brakes.

SCRAPER-TRACTOR HOOKUP

When making a scraper connection to a prime mover as a 4-wheel unit, position the tractor and secure the scraper tongue to the tractor drawbar with the drawbar pin (view A, fig. 13-16). Connect the six hydraulic hoses (fig. 13-17) to their respective openings in the manifold on the headframe. See figs. 16 and 17, page 349.

When making a scraper connection to the I-110 tractor as a 2-wheel unit (view B, fig. 13-16), do not connect the hydraulic hoses until you relieve


"SERVICE" AIR COUPLING
"EMERGENCY" AIR COUPLING.
HYDRAULIC LINES (6)
BOWL LOCK COUPLING
"DUMMY" COUPLINGS FOR TRACTOR AIR LINES
UNIVERSAL COUPLER TAPERED PLUG (4)

115.317

Figure 13-12.—Scraper-to-tractor hose connections.

the pressure in the lines by stopping the engine and working the hydraulic levers. Then, connect the hydraulic hoses and air lines from the tractor to the scraper. Start the tractor engine and operate it at approximately 1200 rpm. Operate the hydraulic controls and check for correct operation. (Remember, pushing a control lever away from you will result in a lowering motion of the component and pulling a control lever toward you will result in a raising motion of the component.)

Operate the tractor engine at maximum rpm and operate all cylinders on the scraper to maximum extension to bleed air from the hydraulic system. Check the hydraulic oil in the prime mover reservoir; add as necessary to maintain proper oil level.

Be sure all safety lock pins and transport pins (travel lock) are disengaged prior to operation.

Connect airbrake hoses and the bowl safety lock hose. Remember that the airhoses are used only when the scraper is pulled by a wheel-type unit.

Be sure the cut-off cocks on the tractor are closed when connecting or disconnecting air brake lines.

Connect hoses at the scraper gooseneck and at the rear of the tractor; make sure EMERGENCY and SERVICE hose connections are correct.

With the tractor running, allow air pressure to build up the scraper air reservoir. Be sure the draincock in the scraper air reservoir is closed. Accumulating air pressure will gradually apply the brakes. The brakes will release when the air pressure reaches approximately 65 pounds. If the brakes do not release after air pressure has built up, check to see if the EMERGENCY and SERVICE lines have been improperly connected

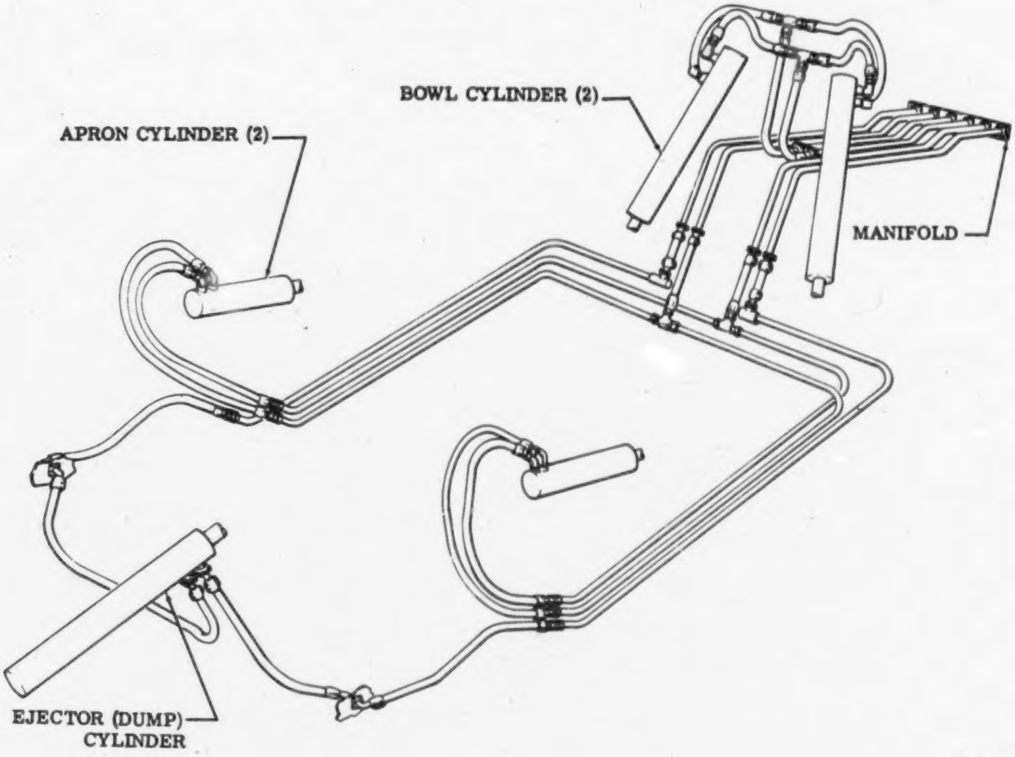


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Figure 13-13. — Scraper hydraulic system.

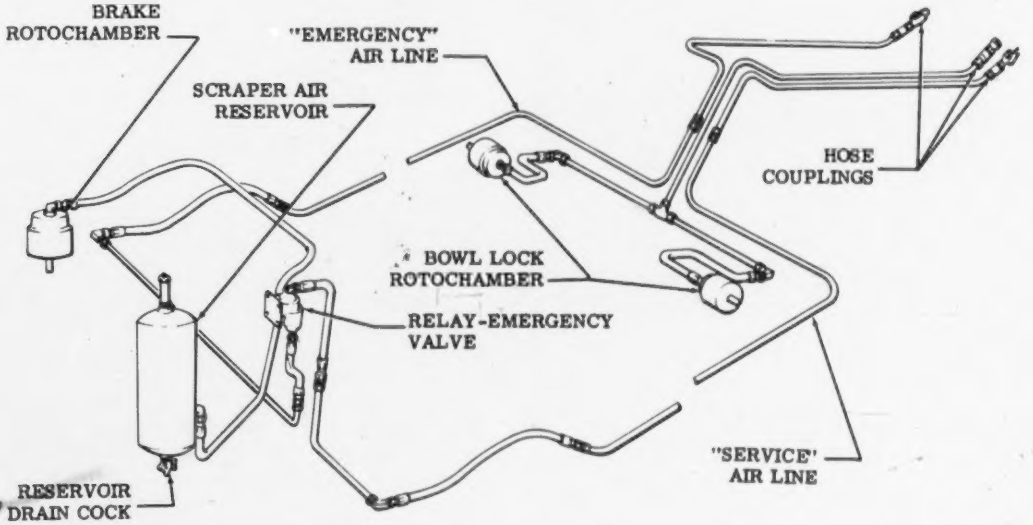

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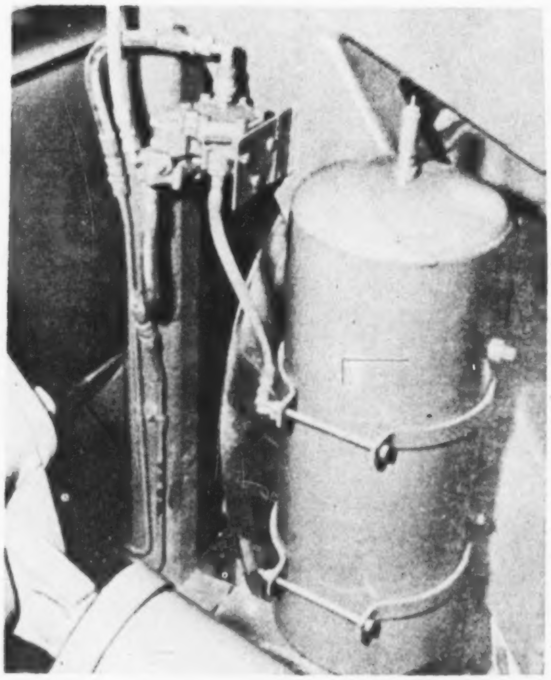
Figure 13-14. — Scraper air system.



115.320
Figure 13-15.—Connections to relay-emergency valve.

between the tractor and scraper. Scraper brakes will be automatically applied by the emergency relay valve when the airhoses are uncoupled from the tractor and there is air in the system. To release brakes under these conditions, open the reservoir draincock and allow air to escape.

After ensuring that all safety and travel lock pins are disengaged, operate the hydraulic control levers on the tractor to check for full action of the bowl, apron, and ejector.

When the cutting edge touches the ground while the scraper is stationary, continued application of the BOWL lever to LOWER position will result in the wheels of the scraper being lifted from the ground. This is normal and necessary to check the full action of the bowl cylinders and all components.

If airbrakes are connected, drive forward a short distance and apply the tractor brakes momentarily as a test for quick application and release of scraper brakes.

Do not depend on airbrakes to hold the scraper stationary. Lower the bowl cutting edge to the ground when stopped. Block the scraper wheels if necessary.

OPERATION OF SCRAPERS

This section provides general information regarding the operation of scrapers used by the SEABEES. For detailed instructions on scraper operation, study the operator's manual provided by the manufacturer of the scraper concerned.

OPERATOR'S DAILY SERVICES

To ensure that the equipment is ready for operation at all times, it must be inspected by you before operation, at intervals during operation, and after operation, so that defects may be discovered and corrected before they result in serious damage or failure. The necessary operator's daily services will be performed before operation. Defects discovered during operation of the unit will be noted on DD Form 2664 for correction to be made as soon as operation has ceased. Stop operation immediately if a deficiency is noted during operation which would damage the equipment or endanger personnel if operation were continued. After-operation services must be performed by the operator after each operating period. Defects or unsatisfactory operating characteristics which cannot be corrected by the operator must be

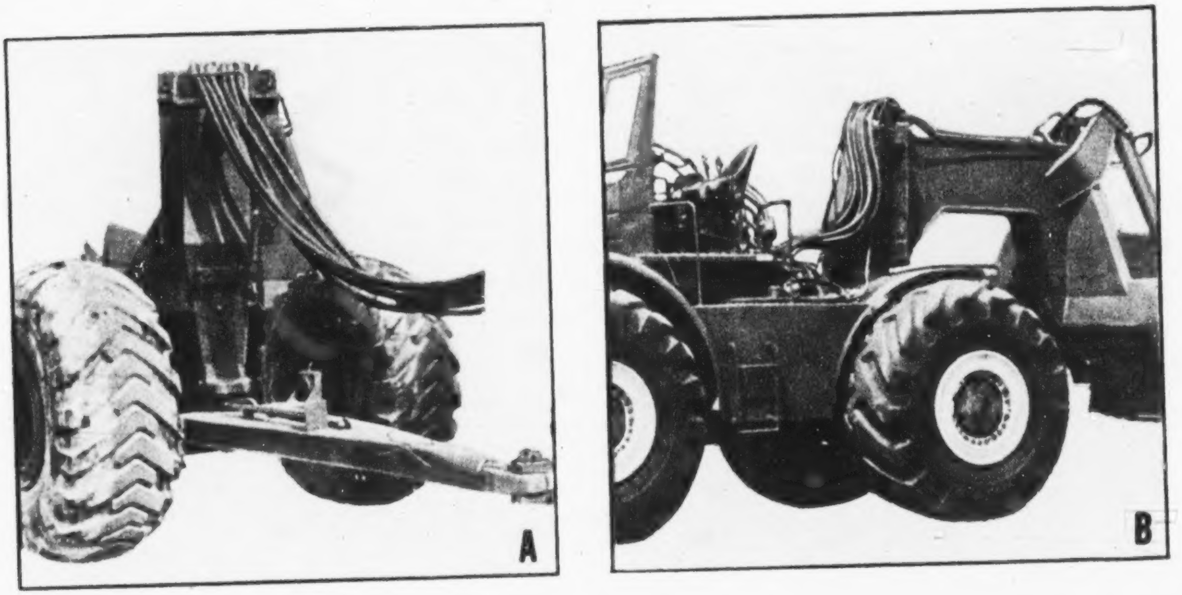


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Figure 13-16.—Scraper connections to tractor.

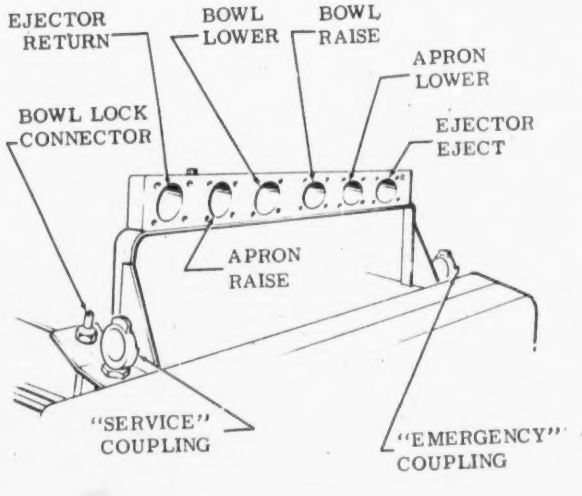

Figure 13-17.—Trailer hydraulic hose connections. 115.322

reported immediately to your crew supervisor and/or to the maintenance section.

Table 13-2 lists the points on the M.R.S. model S-110 scraper to be serviced daily by the scraper operator.

OPERATING CYCLE

The major steps in a normal scraper operating cycle are (1) LOADING in the CUT (a borrow pit, or an area which needs to be cut down to grade is called a cut); (2) HAULING the load to the FILL (an area which needs to be filled up to grade is called a fill); (3) UNLOADING and SPREADING the load in the fill; and (4) RETURNING to the cut. The techniques usually employed in each of these steps are discussed in subsections below.

Loading

Enter the cut with the apron open 4 to 8 inches above the leading edge of the bowl, and the bowl lowered to cut a depth of 1 to 1-1/2 inches. This will leave an opening large enough

Table 13-2.—Operator's Daily Services for Model S-110, M-R-S Scraper

INTERVAL			PROCEDURE
BEFORE OPERATION	DURING OPERATION	AFTER OPERATION	
X		X	LUBRICATION BEFORE OPERATION. Inspect all moving parts for adequate lubrication. Lubricate as necessary. After operation, perform required lubrication services.
X			TIRES. Inspect tires for proper inflation.
X		X	AIR RESERVOIR. Open draincock in bottom of air reservoir; leave open until all air, moisture, and sludge have drained from the reservoir, then close draincock.
X			BRAKE HYDRAULIC RESERVOIR. Check level.
X	X	X	VISUAL INSPECTION. Make a general inspection of the entire scraper for any obvious deficiencies such as hydraulic oil leaks; loose or missing bolts, nuts, hose or tube clamps; bent, binding, or broken parts; rubbing or chafed hoses.
	X		UNUSUAL NOISE OR OPERATION. Inspect for unusual noises or operation, overheating, breakage or worn parts. Inspect bearings and brakes for overheating.
X			ON EQUIPMENT TOOLS. See that all on-equipment tools and accessories are properly accounted for, clean, and in serviceable condition.

115.335

for the material to enter without piling up in front of the apron as shown in figure 13-18, while keeping the apron low enough to retain the material in the bowl.

The gear you shift into to make the cut will depend on the nature of the material being loaded. For light, loose material, you can use a relatively high gear; for heavy, compact material you will have to use a lower gear. To obtain a heaped load it is generally preferable to use a lower gear, even in loose material.

Lower the blade gradually into the ground, to ensure a smooth regular cut. How deep you lower it depends, once again, on the nature of the material and the gear being used. To determine the optimum depth for the gear the prime mover happens to be in, lower the blade until the prime mover engine begins to lug down; then raise it until the engine resumes normal operation.

As the rig moves forward, the cutting edge will cut into the material and force it up into the scraper bowl. As the bowl fills, the material will pile up, first against the ejector, and finally against the back of the apron.

When the bowl is filled to capacity (it is customary to fill a scraper bowl to HEAPED capacity), close the apron and, at the same time, raise the bowl to 1 or 2 inches above the surface of the ground, while continuing the forward motion of the rig. This procedure spreads out any loose material piled up in front of the bowl, thus leaving a smooth, uniform grade for entry to or exit from the cut.

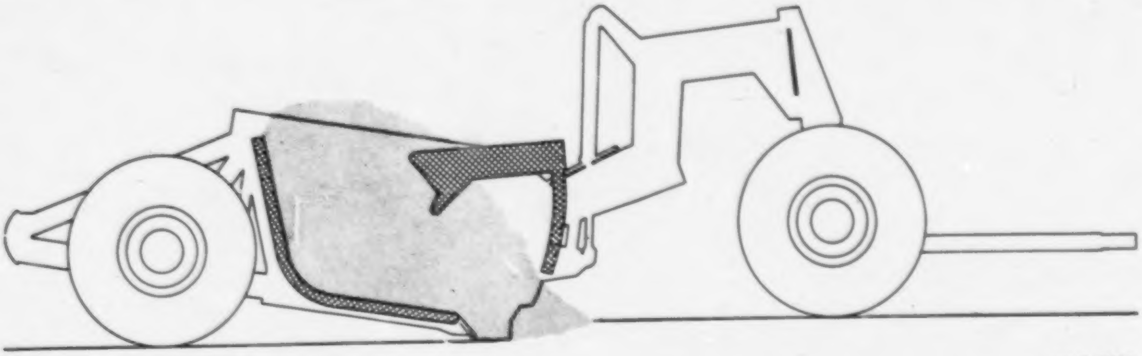

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Figure 13-18.—Scraping and loading position.

Hauling

The closer the bowl of a traveling, loaded scraper is to the ground, the more stable the rig will be and the less danger there will be of overturning. You should, therefore, travel with the bowl as close as possible to the ground, but you must ensure that it is high enough to clear any protruding objects on the haul road. Travel to the fill with the prime mover engine in the highest gear it will stand without lugging down. When hauling downgrade, however, it is NOT always best to travel in a high gear due to safety considerations. Figure 13-19 illustrates the hauling position.

Unloading and Spreading

As you enter the fill, raise or lower the bowl to the desired thickness of the spread. Unload and spread at the highest speed possible, consistent with smooth ejection and flow of material. First, raise the apron to maximum height, to allow the material in it to fall out. Then raise the ejector at an even speed until the material is ejected out of the bowl as illustrated in figure 13-20. (Methods for handling especially sticky materials are covered later in this chapter.)

After the apron has been cleared of material, raise it to the maximum height again and raise the ejector. As the ejector raises, the material will be forced out of the front of the bowl. Do not force the material out too rapidly; if you do, you may cause a pile of earth ahead of the bowl large enough to lug down the engine of the prime mover. If you are starting a new spread, lower the bowl slightly as the rear wheels of the

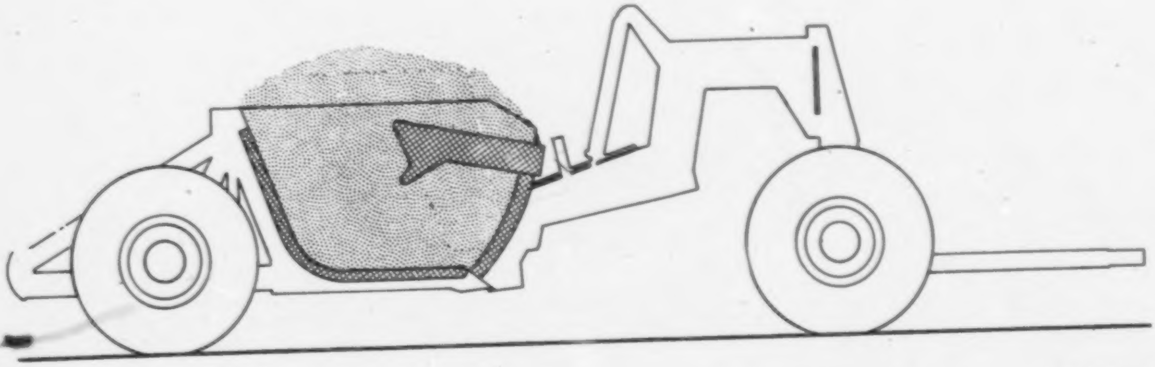

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Figure 13-19.—Hauling position.

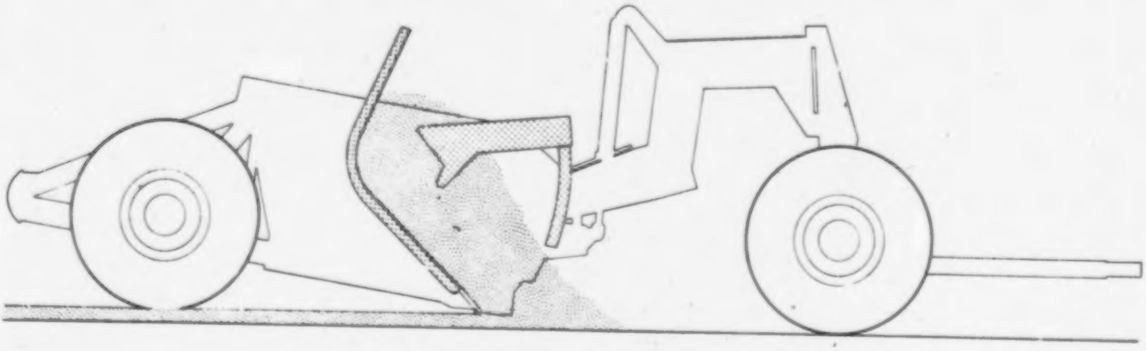

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Figure 13-20. — Spreading and dumping position.

scraper rise on the newly spread material. This prevents the layer from thickening.

Continue to raise the ejector until it is all the way up and the bowl is empty. As the material leaves the bowl, it will be spread to the desired thickness by the bottom of the bowl. When the bowl has been emptied, lower the ejector to its rearmost position, lower the apron, and raise the bowl to the required height for the returning cut.

Returning

Returning to the cut in the highest practicable gear, carrying the bowl as close as possible to the ground, but high enough to clear any obstructions on the haul road. If the haul road has become rough enough to slow traffic, you can smooth it out on the return trip by raising the apron to maximum height, raising the ejector forward to approximately 8 inches from the maximum forward position, and lowering the bowl far enough to fair up the surface as illustrated in figure 13-21.

HANDLING DIFFICULT MATERIAL

The discussion so far has been based on the assumption of normal soil which presents no particular problems of handling. Several types of soils, however, present certain difficulties.

Wet, Sticky Material

When loading wet, sticky material where traction is poor, best results will be obtained by taking

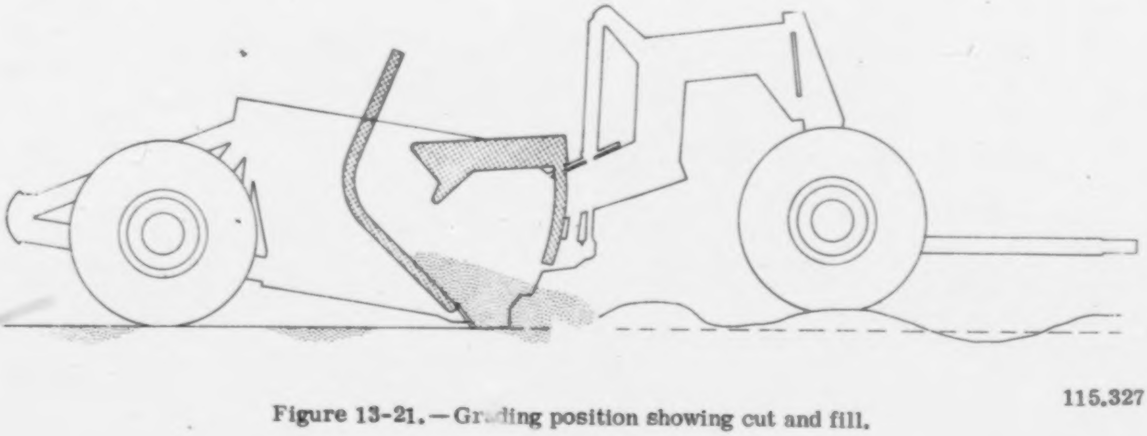

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Figure 13-21. — Grading position showing cut and fill.

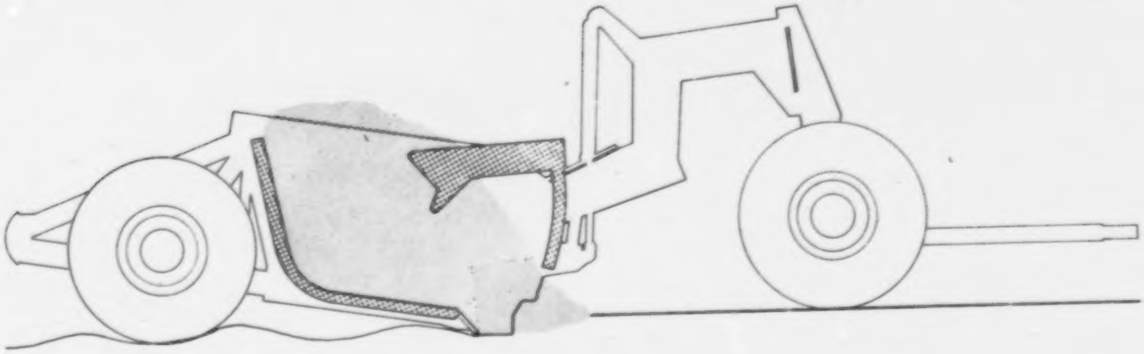

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Figure 13-22.—Sand loading position showing pumping action.

a thin cut and keeping the apron as low as possible to prevent mud from banking up in front of the cutting edge. Straddle loading will also improve performance. When unloading, raise the bowl at least 1 foot before spreading is started to provide clearance for material to pass under the bowl. Then raise the apron to its maximum height and bring the ejector upward and forward slowly 1 foot at a time. After each upward and forward movement, move the ejector 6 inches backward and downward to allow material to fall back and loosen itself.

Loose Sand And Gravel

When loading sand, raise the apron at least 3 feet and drop the bowl while traveling in second or third gear to take advantage of momentum. Load until the engine starts to lug down. Sand will not be piled ahead of the cutting edge. Lower the apron into the pile and raise the bowl at the same time. When engine rpm picks up, lower the bowl and repeat the operation until the scraper is loaded. This is known as PUMPING (see fig. 13-22). After the scraper is loaded, the bowl should be raised only a few inches and held in this position while traveling forward enough to level the sand pile in front of the apron.

Gravel may be loaded in the same manner as sand except that it may be difficult to close the apron when pumping. When this occurs, back up the scraper a few inches with the cutting edge still in the ground and, at the same time, lower the apron while raising the bowl.

Rock

Rock (or boulders) may be loaded without running over the object with the tractor or front wheels of the scraper by following these steps in the order given:

1. Head the tractor for the object.
2. When the tractor is almost on the object, swing the tractor sharply to the side at right angles.
3. Then, straighten the tractor and move alongside of the object.
4. When the scraper wheels pass the object, swing the tractor at sharp angles in front of the object.
5. Then, straighten the tractor quickly. The scraper wheels will also straighten and straddle the object, which will be between the wheels and the blade. Drop the blade and load the bowl with dirt and rock.

Remember to drive slowly to prevent damage to the scraper.

To unload a boulder, stop the rig, raise the apron, and pull the ejector forward. If a boulder is tilted in such a manner as to prevent it from clearing the apron, retract the ejector to allow the boulder to settle back flat; then, bring the ejector forward again.

After the object has fallen out, turn the prime mover and back up, so you can pull away without contacting the object with the rig.

HAND SIGNALS

The hand signals used in scraper operations are depicted in appendix I. It is important that you not only recognize and understand these hand signals when operating scrapers, but also be able to give them when called upon to act as a signalman during scraper operations.

SECURING

When securing a scraper towed by a crawler-mounted tractor, position the scraper for traveling by lowering the ejector to its rearmost position, lower the apron, and raise the bowl to the required height. Then drive the tractor to the designated securing area, and position the rig in a safe manner. After the tractor has come to a standstill, lower the scraper unit to the ground and block the scraper wheels if necessary. Set the tractor brake lock and place the transmission in neutral.

Allow the tractor engine to throttle down to slow idle (no load) for 3 to 5 minutes and then move the speed control lever to shut-off position to stop the engine. After the engine stops, place the electrical system master switch in the "OFF" position. Drain the air tanks on the scraper by opening the drain cocks.

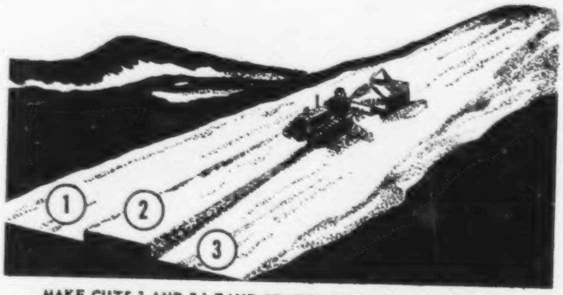
PRODUCTION TECHNIQUES

To obtain maximum production with scrapers, it is necessary to break the basic earth hauling cycle into specific operations. The logical breakdown is loading, hauling, and spreading.

When loading or digging downhill with a scraper, make use of the force of gravity on the tractor and scraper to obtain larger loads in less time. The added force of gravity is 20 pounds per gross of weight per 1 percent of downhill grade. The downhill pull will add more material per load, and the added material will, in turn, increase the total gravitational force.

Using the straddle loading technique (fig. 13-23) gains time on every third trip because the center strip loads with less resistance than a full cut. After the first scraper has made a cut, the second scraper should make a parallel cut leaving a 4- or 5-foot wide island between the two cuts. The third scraper can straddle this island of earth to obtain its material rapidly.

Push loading (fig. 13-24) normally is used to obtain maximum production. Crawler tractors



MAKE CUTS 1 AND 3.LEAVE CENTER STRIP ONE-HALF OF BLADE WIDTH.STRADDLE STRIP AND MAKE CUT.

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Figure 13-23. — Straddle loading.

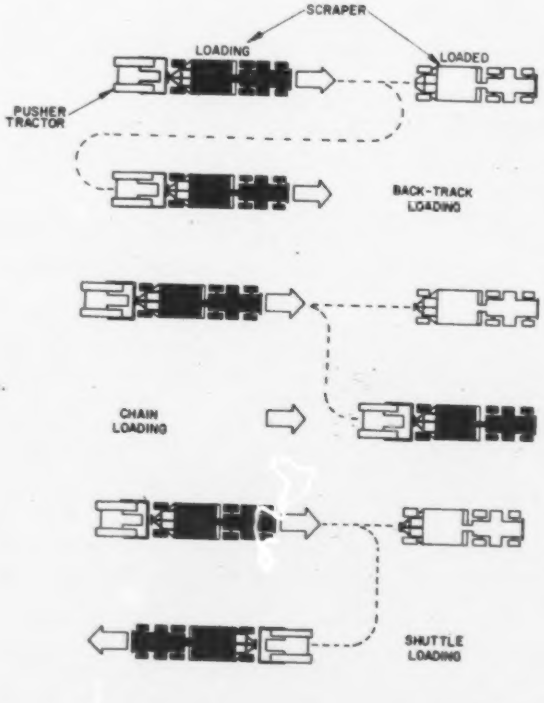

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Figure 13-24. — Push loading methods.

and occasionally rubber-tired tractors with scrapers may load without assistance, but generally it is more economical to use pusher assistance to reduce loading time. With few exceptions, pusher assistance for self-propelled, rubber-tired scrapers is essential to decrease loading time and tire spinning, thereby increasing tire life.

Generally, backtrack loading is used where the cut is fairly short and it is impractical to load in both directions. This is an inefficient method due to the time spent in backing up and maneuvering for the next load. If the cut is wide enough, other loading methods should be used.

Chain loading is employed where the cut is fairly long; this method makes it possible to pick up two or more scraper loads without backtracking. The pusher loads one unit, then moves in behind another unit, moving parallel to the first in an adjacent lane.

Shuttle loading is generally used for short cuts where it is possible to load in both directions. The pusher pushes one unit in one direction, then turns and push loads a second unit in the opposite direction.

Minimum loading time is of major importance when considering maximum output. Pusher loading scrapers generally should be loaded within 1 minute and within a distance of 100 feet. Additional time and distance may be used to obtain extra yardage if the haul is long enough and the added yardage is great enough to offset hauling fewer loads because of longer loading time.

Equipment operating in the borrow pit should be the best available. The loading unit should not depend on the pusher to do all the work. Conversely, the wheels or tracks should not be spun in an effort to pull away from the pusher. Traffic control within the borrow pit will reduce wait time and excess travel of earthmoving equipment.

The operator should enter the loading area at a high return speed. If the approach and cut are relatively level and smooth, this is a safe and practical practice. The cut supervisor or pusher tractor operator should indicate the loading lane. The pusher tractor should be waiting about 45° off the lane to be cut, allowing the loading unit to come in with the least delay and difficulty. The scraper operator should start the loading operation before the push tractor makes contact. As the scraper speed decreases the pusher should make contact and start assisting in the loading operation. The pusher should continue pushing after a full load is gained, thus giving the scraper a boost out of the area.

The scraper should leave the cut as fast as possible, traveling a few feet before the bowl is lifted to the carrying position. This will spread the loose material that has been piled up in front of the cutting edge and result in a smooth cut, allowing the following scraper to maintain speed.

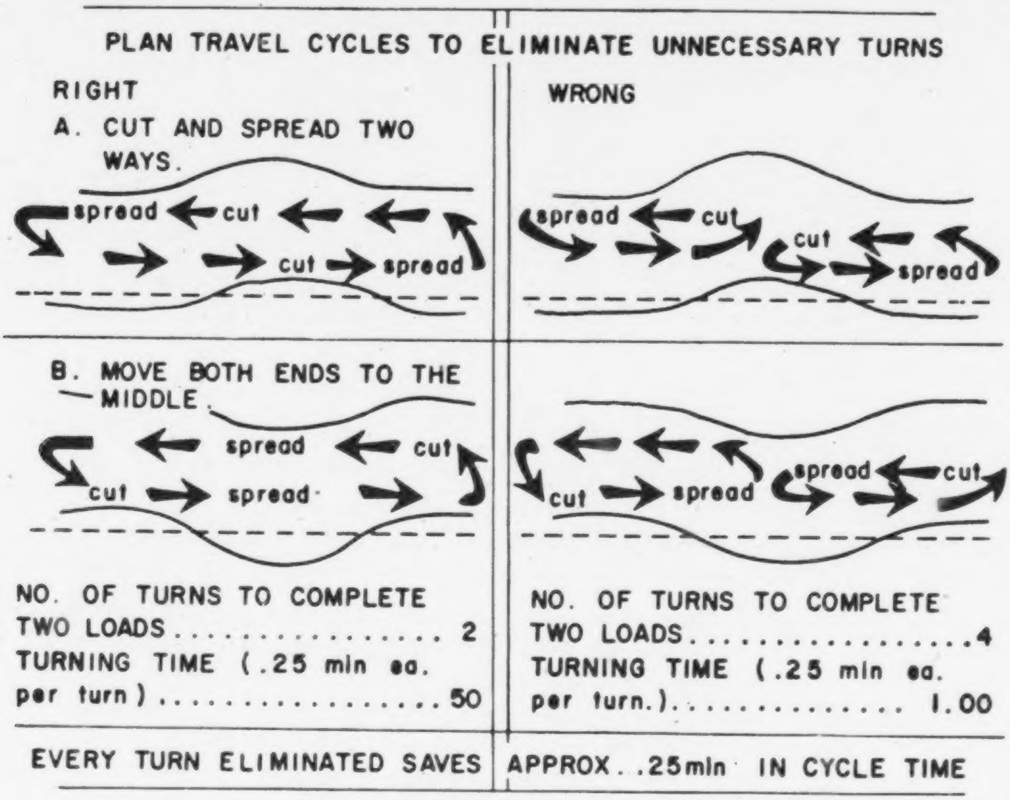
Maintaining adequate drainage throughout the borrow pit operation will reduce compulsory downtime caused by bad weather. Loading cuts should be made in a manner that ensures uniform graded slopes.

When loading in a through-hill cut, it is important that the loading area be cut so that the centerline remains the high point. In order to maintain this desired crown, turn the empty scraper from the center of the cut to the outside so the scraper will come at an angle against the side slope of the cut. Drop the scraper bowl and start digging when the tractor is parallel to the slope. This will cause the scraper to dig lower on the slope side. It also allows the equipment to work the outer edge of the cut more effectively, makes it easier to maintain the desired bank slope, and provides drainage of the cut area.

Travel time includes haul time and return time. Here the power and characteristics of the tractor attached to the scraper are of major importance. Tractors can tow large size scrapers, but at reduced speeds. Careful judgment must be exercised when teaming up tractor and scraper (where possible) to ensure that the end result will provide maximum production. The job should be planned to avoid adverse grades because they can drastically reduce production. Haul roads should be laid out so no unnecessary time is wasted in maneuvering. Remember that the shortest distance between two points is always a straight line; follow this rule when grades permit.

Long turns mean longer, slower cycles. Avoid them. Turns should be made on the shortest radius possible, and at the highest speed consistent with safety. Valuable time can be saved on short-radius turns.

On scraper work, as much as one-half of the turning can be eliminated by using the load pattern shown in figure 13-25. If possible, load alternately at either end of the fill (fig. 13-26), or the scraper can load at the center point and spread in opposite directions. Output is increased in either case.


PLAN TRAVEL CYCLES TO ELIMINATE UNNECESSARY TURNS
RIGHT
WRONG
A. CUT AND SPREAD TWO WAYS.
spread
cut
cut
spread
spread
cut
cut
spread
B. MOVE BOTH ENDS TO THE MIDDLE.
spread
cut
cut
spread
cut
spread
spread
cut
NO. OF TURNS TO COMPLETE TWO LOADS 2
TURNING TIME (.25 min ea. per turn) 50
NO. OF TURNS TO COMPLETE TWO LOADS 4
TURNING TIME (.25 min ea. per turn.)............. 1.00
EVERY TURN ELIMINATED SAVES APPROX. .25min IN CYCLE TIME

115.330

Figure 13-25.—Cut and spread sequence.

Space rigs efficiently. Rigs should be teamed according to speed whenever possible. Put crawler tractor scrapers on one section of the job and self-propelled, rubber-tired scrapers on another section. They should use different haul roads if at all possible. No haul rig should travel faster than the unit ahead of it. The operator should speed up to close a long gap, and slow down when he is too close to the rig ahead. The operator should dump at the end of the fill nearest the cut when he is lagging far behind the next scraper, and at the far end when he is close to the next scraper.

Haul roads should be kept in good condition. Eliminate ruts and rough washboard surfaces with grader or dozer. If neither is available, the scraper operator should drop his cutting edge occasionally on his return trip to level high spots and fill holes. A well maintained haul road permits traveling at higher speeds, increases safety, and reduces operator fatigue and equipment wear.

Sprinklers should be used to reduce dust. Roads kept moist (but not wet) will pack into hard, smooth surfaces, permitting higher travel speeds. Dust tends to get into all parts of the scraper, increasing lubrication time and causing additional wear. Reducing the dust also ensures better visibility and reduces the chance of an accident.

On the haul roads, the unit should travel in the highest gear that is safe for road conditions. When possible, the scraper bowl should be carried fairly close to the ground. This lowers the center of gravity of the scraper and the chance of upsetting is less.

Avoid unnecessary lugging. The operator should shift down when momentum is lost. Lugging the engine usually results in slower speed than the top range of the next lower gear. Even

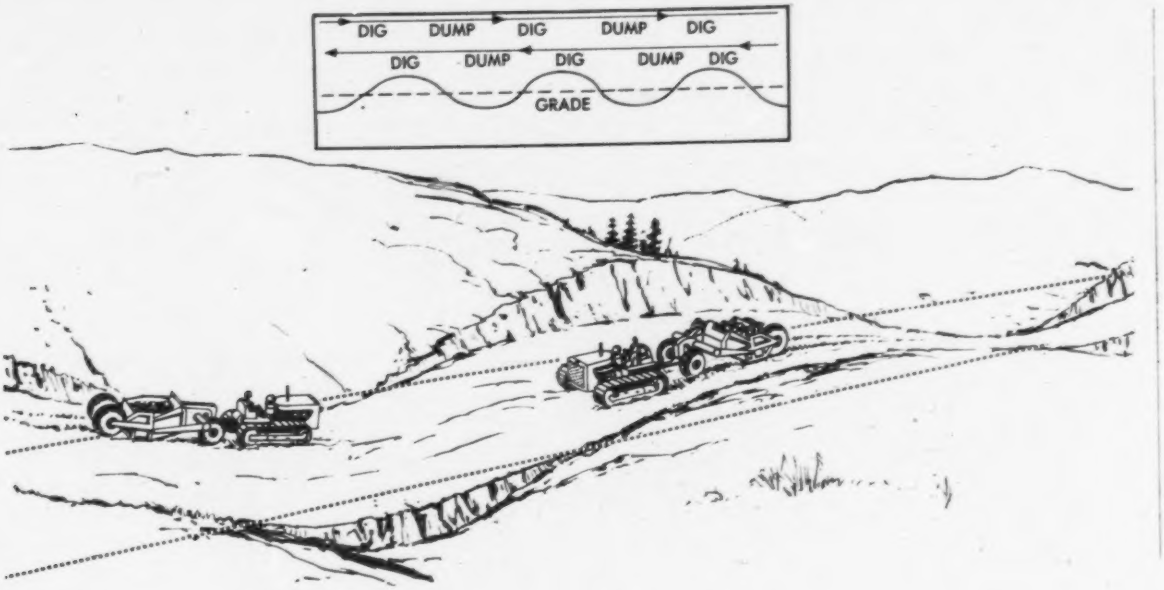


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Figure 13-26.—Two cuts with common fill.

though the machine can make it, it is better to shift down and accelerate faster.

In making scraper spreads, spread the first load at the start of the fill. Travel with subsequent loads over the previous fill (fig. 13-27), if lifts are small. Place each following spread, starting at the end of the previous layer. Finish spreading in one full length before starting a new lane, so that rollers can begin compaction. Route the scrapers to compact the fill. Overlapping tracks aid the compaction of the entire area and reduce the compaction time necessary with a roller.

Spread in the highest gear permitted by the fill area conditions and the characteristics of the fill material. Slowly dribbling the load at low speed slows down the cycle and leaves a rough track.

Time should not be wasted on the fill. As soon as the load is dumped, the rig should get back on the haul road and return to the cut as fast as possible. Plan the exit from the fill to avoid soft ground and detours around trees or other obstacles.

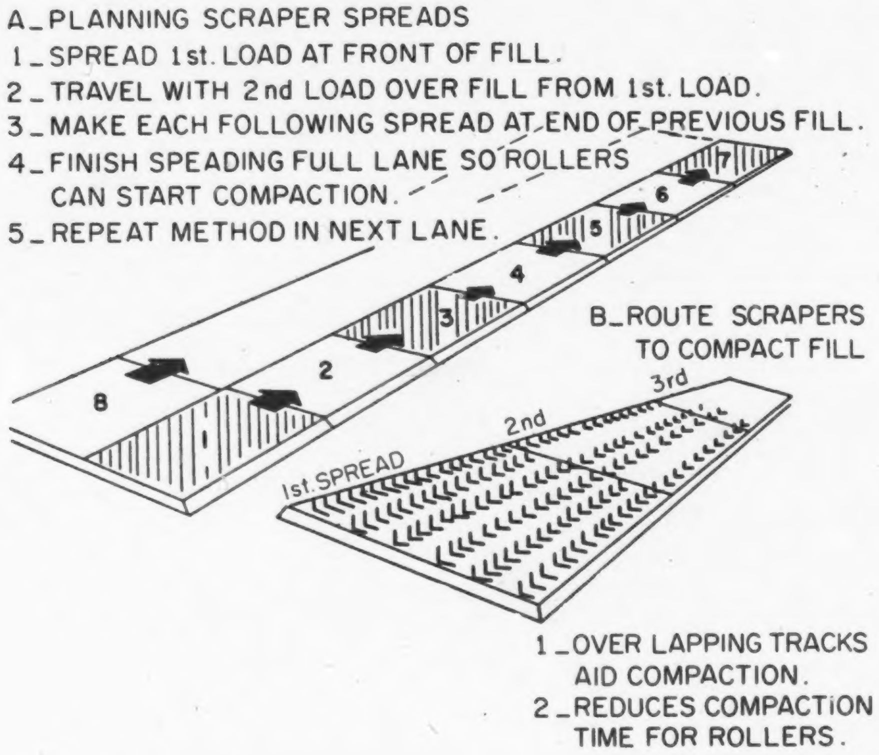
Make the fill high on the outside edges (fig. 13-28). This prevents the scraper from sliding over the slope. Accurate slopes can thus be maintained to desired heights, eliminating the necessity of handwork. If the fill is not made in this manner, the scraper may slide over the fill, and the slope would be damaged. It would also be impossible to maintain an accurate degree of slope, because of the tendency to work away from the edge of the fill. Before closing down the job for any period of time, fill in the low center for better drainage in event of rain.

SCRAPER MAINTENANCE

Preventive maintenance is the responsibility of the activity using the equipment. It is performed at weekly, monthly, quarterly, and semiannual intervals. The operator will assist maintenance personnel in performing preventive maintenance services. Preventive maintenance inspection and services required for the model S-110, M.R.S. scraper are listed in table 13-3.

LUBRICATION

The life and performance of a scraper depend on the care that it is given. Proper lubrication, performed at definite intervals, will aid


A_PLANNING SCRAPER SPREADS
1_SPREAD 1st. LOAD AT FRONT OF FILL.
2_TRAVEL WITH 2nd LOAD OVER FILL FROM 1st. LOAD.
3_MAKE EACH FOLLOWING SPREAD AT END OF PREVIOUS FILL.
4_FINISH SPEADING FULL LANE SO ROLLERS CAN START COMPACTION.
5_REPEAT METHOD IN NEXT LANE.
7
6
5
4
3
2
8
1
B_ROUTE SCRAPERS TO COMPACT FILL
3rd
2nd
1st. SPREAD
1_OVER LAPPING TRACKS AID COMPACTION.
2_REDUCES COMPACTION TIME FOR ROLLERS.

115.332

Figure 13-27.—Sequence of scraper spreading.

greatly in prolonging the life of the scraper and in reducing operating expense. Lubrication instructions are included in the operator's manual for the particular scraper you are using.

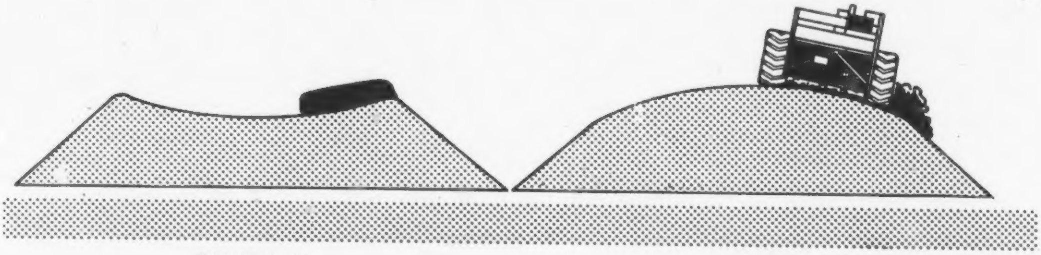
SCRAPER TIRES

Inspecting, checking and maintaining scraper tires is another major maintenance service performed by the operator. Inspection consists of checking for missing valve caps, leaking valves, cuts, breaks, abrasions, embedded foreign matter and other damage. Minor cuts and snags can be repaired without dismounting the tire from the rim. Repair cuts and breaks in the tires as soon as possible to prevent further damage.

With minor cuts and snags, use a sharp pointed knife to skive around any cut in the tread area which might hold pebbles or dirt. The angle of the skive should be no more than sufficient to prevent the holding of foreign matter and should not extend into the tire carcass. If the cut extends into the tire carcass, remove the tire for repair.

Ordinary punctures can be repaired without removing the tire from the rim by using tire repair plugs. The tire must be removed from the rim to repair large punctures or cuts. Irregular punctures or cuts less than 1/2 inch can be repaired with a plug and a hot patch. After the plug has been inserted, trim the plug off flush with the inside of the casing, buff, and apply the hot patch.

Punctures 1/2 inch or larger, or bruise breaks, will require sectional or reinforced vulcanized repair. Always cover the repair patch with a layer of cushion gum to ensure airtight repair. Any cords of the inside ply that are exposed by buffing and are not covered by



RIGHT WAY

TO MAINTAIN FILL SLOPE

1. MAKE FILL HIGH ON THE OUTSIDE
2. THIS PREVENTS SCRAPER FROM SLIDING OVER SLOPE
3. ACCURATE SLOPES CAN THUS BE MAINTAINED TO DESIRED HEIGHTS ELIMINATING NECESSITY FOR HANDWORK
4. IF WET CONDITION PREVAILS ARRANGE FOR DRAINAGE TO PREVENT WATER POOLING IN CENTER OF FILL

WRONG WAY

RESULT OF INCORRECT METHOD

1. SCRAPER WILL SLIDE OVER SIDE OF FILL
2. DAMAGE TO SLOPE WILL BE CAUSED
3. IMPOSSIBLE TO MAINTAIN ACCURATE DEGREE OF SLOPE WILL HAVE TENDENCY TO WORK AWAY FROM EDGE OF FILL

115.333

Figure 13-28.—Maintaining desired fill slope.

the repair patch should be coated with cushion gum to prevent air leakage into the carcass plies.

If the scraper tire has to be removed, secure the scraper properly and block the wheels to prevent the scraper from rolling. Jack up the wheel until the tire clears the ground. Block up the axle with safety blocks or timbers.

One of the following pieces of equipment should be used to lift the tire and rim assembly from the scraper:

1. Chain falls or block and tackle.
2. Forklift truck.
3. Boom truck.
4. Tripod tire changing tool.

After the tire and rim assembly (fig. 13-29) have been removed from the scraper, ensure that the tire is completely deflated by removing the valve cap and core prior to dismounting the tire from the rim. This procedure is important even if the tire has blown out because, in some cases, enough pressure may remain in the tire to blow off a loosened flange and cause serious injury. When all air has been exhausted from the tire, replace the valve cap on the valve to protect the valve threads from damage.

When you dismount the tire from the rim, break the bead of the tire loose from the bead seat band (4) on the gutter side of the rim by inserting a pry bar into one of the slots and twisting it in a circular motion. Alternate with a second tool in this manner around the flange. (A hydraulic bead breaking tool may also be used for this purpose.)

Push the bead seat band back from the lockring (6) by placing the hooked end of a pry bar in the rim gutter and prying on the bead seat band.

Remove the lockring from the rim by inserting a pry bar into a breaking notch and moving the tool toward the center of the rim, prying the lockring up and out of the lockring groove. (A slight tapping with a lead hammer may be needed to complete the lockring removal.)

Remove the rubber O-ring (5) from the rim base (1). Then insert the hooked ends of the pry bars between the bead seat band and the flange (2) and pry the band from the rim.

Table 13-3.— Preventive Maintenance Inspection for Model S-110, M.R.S. Scraper

	W	M	Q	S
a. GENERAL. DAILY SERVICES. Check and perform services listed in Table 13-2 OPERATOR'S DAILY SERVICES.				
LUBRICATION. Inspect entire unit for missing or damaged lubrication fittings and indication of insufficient lubrication. Lubricate if necessary.	X			
TOOLS AND EQUIPMENT. Inspect condition of all tools and equipment assigned to the tractor. See that the tool box is in good condition, securely mounted, and that the lid closes and fastens properly.	X			
APPEARANCE. Inspect the general appearance of the unit, paying particular attention to cleanliness, legibility of identification markings, and condition of paint. Correct or report any deficiencies noted.	X			
b. AIR OVER HYDRAULIC BRAKE SYSTEM. COMPRESSED AIR RESERVOIR. Check for insecure mounting, exterior corrosion, and interior sludge. Tighten mounting bands and clamping bolts as required. Clean and paint exterior if necessary. If reservoir contains sludge that will not drain out, remove and clean reservoir interior with hot water and steam.		X		
SAFETY VALVE. Check safety valve for proper operation as follows: with system charged, grasp the pin which extends from the end of the valve body and pull out momentarily - air should escape. Check the valve for leakage by coating with soap suds. Correct excessive leakage.		X		
RELAY-EMERGENCY VALVE. Check for proper operation of the scraper brakes. Brakes must apply and release promptly. Replace defective valve.				X
BOWL SAFETY LOCK ROTOCHAMBER. Check for proper operation and leaking diaphragm. To check for leaky diaphragm, remove the push rod boot from the rotochamber body. Coat the opening between the push rod and the push rod hole in the body with soap suds. Replace rotochamber if leakage is found.				X
BRAKE ROTOCHAMBER. Check for proper operation and leaking diaphragm. Repair or replace rotochamber if leakage is found.				X
CHECK SYSTEM LEAKAGE. (Leakage must be tested with scraper air lines connected to a source of supply.)		X		

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Table 13-3.—Preventive Maintenance Inspection for Model S-110, M.R.S. Scraper—continued

	W	M	Q	S
b. AIR OVER HYDRAULIC BRAKE SYSTEM (CONT) GENERAL. Check all hoses, tubing and clamps for secure mounting and sound condition.		X		
HYDRAULIC BRAKE MASTER CYLINDER. Check for leaks and for secure mounting. Tighten cap bolts to 130 to 140 ft. lb. to assure proper support.	X			
HYDRAULIC BRAKES. Check visible bolts for tightness. Check drums for overheating after operation. Open bleeders to check for trapped air or vaporized oil. Check lining wear by applying brakes and looking into the spring openings in the brake frames; a clearance of 1/8 inch between the top of the spring opening and the ledge of the shoe indicates linings and springs must be replaced.	X			
c. HYDRAULIC SYSTEM. CYLINDERS. Check for leaks and inability to hold load. Tighten cylinder cartridge nuts or repair as required.	X			
GENERAL. Check lines for leaks.	X			
d. AXLES, TIRES, WHEELS. TIRES. Inspect all tires for low-air pressure, wear, cuts, imbedded foreign matter, and missing valve caps.	X			
AXLES. Inspect for leaking oil seals and improper bearing adjustment. Correct as necessary.	X			
e. FRAME BODY Inspect for cracks, breaks, broken welds, and for loose or missing bolts. Check for improper operation of components such as binding. Inspect the ejector rollers for excessive wear, damage or loose mounting. Inspect cutting edges - replace as necessary.	X X			

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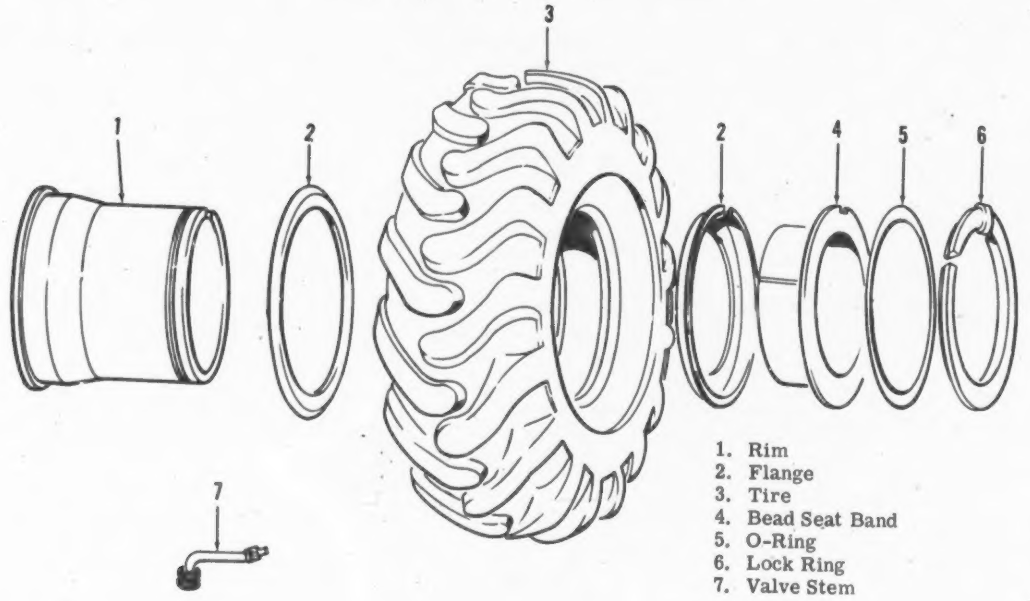

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Figure 13-29.—Wheel equipment, exploded view.

Lift the flange from the rim. Break the bead loose on the opposite side of the tire and remove the tire.

If desired, remove the valve stem (7) by removing the spud nut from the tire side of the rim.

Check the interior surface of the tire to determine its condition. Inspect for cuts or fabric breaks that have penetrated the tire body. The tire should be inspected closely for any sharp-pointed object that may have penetrated the tire body but is invisible from the outside. All dust, dirt, water, or other foreign matter should be cleaned from the inside of the tire.

Carefully inspect the wheel and rim parts for cracks, bends, distortion, or other damage.

Never use a bent or distorted lockring when remounting a tire; it may fly off with killing force during inflation of the tire.

Clean all rust and dirt from the wheel and rim parts and apply a coat of good primer. Allow the paint to dry thoroughly before remounting the tire.

The rim parts used with tubeless tires form an important part of the air chamber. Therefore, they should be carefully checked for distortion or damage that would prevent an effective air seal when the tire and rim are reassembled.

Rubber O-rings are air seals for tubeless tire and rim assemblies and should be carefully handled to provide an airtight seal when the tire is mounted on the rim.

Clean all dirt, corrosion, water, or other foreign matter from the rim parts. Pay particular attention to the rubber O-ring grooves. Apply a good coat of anticorrosive paint to the rim parts.

When remounting the tire on the rim, insert the valve stem into the rim valve hole and secure tightly with the hex nut on the tire side of the rim.

Be sure you note the following:

THE TRACTION DIRECTION ARROW ON THE TIRE TREAD IS TO POINT IN THE OPPOSITE DIRECTION AS THE ROTATION ON THE WHEEL.

Lubricate both tire beads and the rubber O-ring with a thin solution of high-grade soap flakes and water or a Navy-approved nonpetroleum lubricant.

Lay the rim base on blocks or a mounting stand with the gutter side up.

Place the rear flange over the rim base and lower into position. Make sure that the drive lug on the flange engages in the slot of the back section of the rim.

Make certain that the valve assembly is securely in place. Position the tire over the rim base with the hoist and lower onto the rim.

Position the front flange on the rim base with the flange drive lug approximately 5 degrees in a clockwise position from the drive lug in the rim base.

Line up the drive lug in the flange and the drive lug slot in the bead seat band and lower into place on the rim base.

Tap the bead seat band so that it will drop below the O-ring groove base. Place the lockring in the lockring gutter and tap into place with a lead hammer. The drive lug on the lockring must fit into the slot in the gutter.

Lubricate the rim base O-ring and insert it in the O-ring groove in the rim base behind the lockring.

Lift the tire upward to effect a seal between the bead seat band and the O-ring in the rim base so that the tire can be inflated. Inflate the tire pressure to the specified minimum necessary to seat the beads against the flange; then reduce the air pressure to the recommended value.

As a safety measure, make sure that all rim parts are correctly assembled and interlocked before starting inflation. It is necessary that clamp-on inflation hoses, safety chains, a cage, or some other safety device be used during inflation.

Inflation air lines should have traps to prevent airborne moisture or oil from getting into the tire and causing rim corrosion or tire deterioration.

SCRAPER SAFETY

Various safety precautions applicable to scraper safety have been pointed out in preceding sections of this discussion. Some additional precautions to be observed are listed below.

The operator should never operate equipment at speeds that are unsafe. If you have to pull the scraper off a project, reduce its speed before leaving the immediate construction site. Choose the pulloff point or the parking area with care. A sudden dropping of one wheel in a hole or rut could cause a violent tilt of the scraper, with possible personal injury by throwing you off the rig or against a control or the steering wheel (if so equipped).

Before any work is done on scraper cutting edges, the scraper bowl must be blocked up, and the apron secured by positioning and locking with the safety locks and pins provided.

Keep the prime mover operating platform clear of debris, grease, oil, and mud, any of which can cause the operator to slip or fall, and injure himself.

Never kick your prime mover out of gear when going downhill; the increased speed will make control of the scraper very difficult. Keep the prime mover in gear at all times when operating and use your brakes to control speed. If the brakes fail to hold the load, you should lower and drag the scraper bowl.

While operating a scraper, don't try to control traffic; competent signalmen will be assigned to direct traffic.

Secure the scraper by setting the scraper bowl on the ground when the unit is not operating.

Do not dump when turning.

When working on a slopes, always turn uphill.

Do not drop the bowl suddenly; ease the cutting edge into the ground.

Load and spread on downgrade, whenever possible.

When constructing a fill, keep the outside edges high and the center low to prevent the scraper from sliding over the shoulder.

Never travel over uneven or rough terrain with the ejector forward and the apron fully raised.

If the rubber-tired prime mover begins to fall off the fill, steer it downhill; drop the bowl, and rapidly accelerate to maximum rpm. DO NOT attempt to turn the unit back up the slope. DO NOT stop the forward motion of the scraper unit if there is any danger of the unit tipping over.

CHAPTER 14

ROLLERS AND DITCHERS

The primary objective of compacting soil is to obtain a density that will provide the desired strength and will carry specified loads without undue settlement and/or form a closed barrier to the flow of water. To accomplish compaction, various types of compaction equipment—sheepsfoot rollers, pneumatic-tired rollers, steel-wheel rollers, vibratory (self-propelled or towed) rollers, and others, are used.

During project construction, excavation may be required to permit installation and burial of conduit. In order to accomplish this task, ditchers are employed.

Before proceeding let us distinguish between a ditch and a trench. A DITCH is a slot cut in the earth's surface and left open. A trench is a temporary scar in which a conduit is placed and covered.

General information on starting, operating, and maintaining rollers and ditchers is presented in this chapter. Details are given on the capabilities, gross limits, optimum working distances, and utilization of rollers and ditchers. Safety precautions to be observed when operating or working near rollers and ditchers also are covered.

POWER ROLLERS

ROLLERS are used mainly for compacting road, highway, and airfield subgrades and paving materials other than concrete. A SMOOTH-STEEL roller (one on which the roll surfaces consist of smooth, cylindrical steel plate) is used for both compacting and smoothing. A TAMPING roller (one on which the cylindrical steel roll surface is studded with numerous projections called FEET) is used for compacting only. Most smooth, steel rollers are self-propelled POWER rollers, but some are TOWED rollers which must be towed by a prime mover. Most tamping rollers are towed rollers.

Good use may be made of other kinds of construction equipment for compacting purposes, particularly crawler-type tractor units, hauling units, and rubber-tired scrapers.

Various rollers are used for compaction of different types of materials; each type of roller compacts different soils at different depths, speeds, and bearing pressures.

Some of the main types of powered rollers are: the 3-WHEEL roller, the TANDEM roller, the PNEUMATIC-TIRED roller, and the VIBRATORY roller; the first three rollers may be referred to as static rollers.

THREE-WHEEL ROLLERS

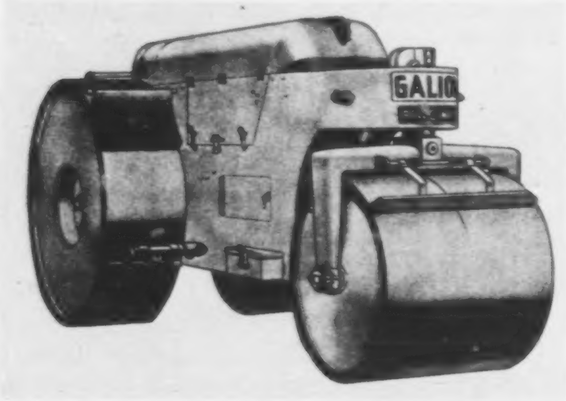
The 3-wheel roller, shown in figure 14-1, is used in the construction of most asphaltic surfaces, and in rolling gravel or aggregate roads and some subgrades. The roller produces a smooth solid surface, but does not always compact deeply in proportion to its weight, which is usually between 5 and 15 tons.

As you can observe by looking at figure 14-1, the 3-wheel roller has a pair of large drive rolls in the rear, and a smaller but wider two-piece steering roll in the front. Compression produced by the 3-wheel roller is usually measured in pounds per lineal inch of the roll width. You will find that compression is much greater in the rear rolls, which produce a kneading action that assists compaction.

The 3-wheel roller is best suited for initial compaction (breakdown rolling) of hot-laid asphaltic materials. It is not generally used for initial rolling of cold-laid pavements, but may be used to complete compaction.

TANDEM ROLLERS

The 2-axle tandem roller (fig. 14-2) has a single large-diameter drive roll at the front and a single tiller roll at the rear. The 3-axle tandem roller (fig. 14-3) has a large diameter



29.73.3

Figure 14-1. — Three-wheel roller.

drive roll at the front and two small-diameter tiller rolls at the rear.

These types of rollers are used for initial and finished rolling of cold-laid bituminous surfaces and finish rolling of hot-laid bituminous surfaces. They may also be used for compacting thin layers of soil. Damage may be caused to the soft metal rolls of the tandem roller if it is used for compacting a base course consisting of hard angular material.

The 2-axle tandem roller may be used to roll lengthwise, across, and diagonally. The 3-axle tandem roller should only be used to roll lengthwise to the roadway.

The primary use of the 3-axle tandem roller is compacting and smoothing flexible pavement surfaces of asphalt and bituminous concrete. High spots are leveled with a high, intensive compression weight to exacting specifications while the material is in a semifluid or plastic condition.

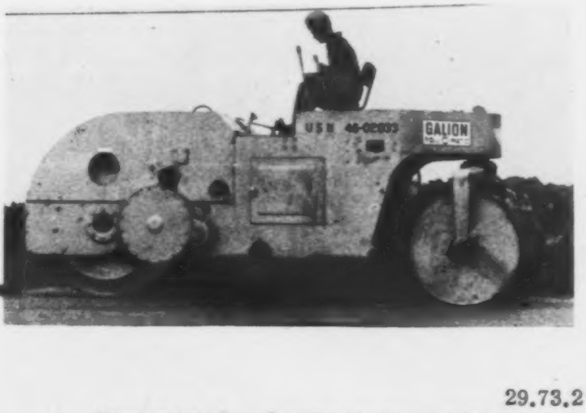


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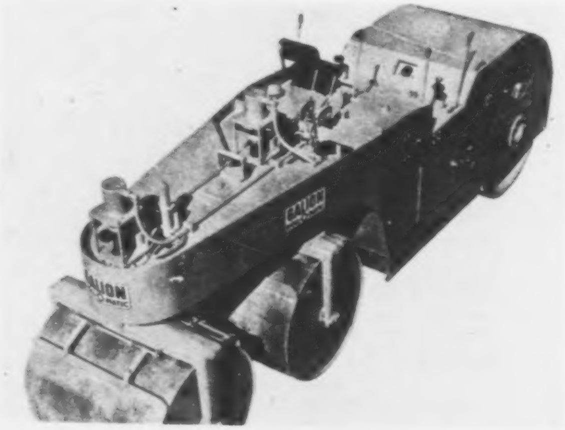
Figure 14-2. — 2-axle tandem roller.



29.73.1

Figure 14-3. — 3-axle tandem roller.

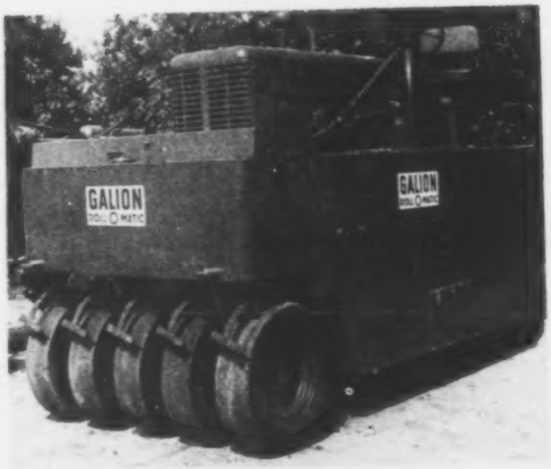
PNEUMATIC-TIRED ROLLERS

The 9-wheel, self-propelled pneumatic-tired roller, shown in figure 14-4, is used in conjunction with steel-wheel rollers when compacting asphalt, base course, and subbase material, as well as for soil stabilization, seal coat, patch work, and compaction of clay and silt.

Some self-propelled rollers are equipped with conventional-type steering using a single king-pin suspension which reduces stability and makes operation on uneven ground hazardous. Other rollers are equipped with a three-point suspension steering system providing for maximum stability and support across the entire front end of the roller. Use of these rollers gives very satisfactory results in compacting materials.

SELF-PROPELLED VIBRATORY ROLLERS

The self-propelled vibratory roller (fig. 14-5) is an ideal selection of equipment for compacting road subgrades, base courses, and shoulders. This roller can also be used for rolling of



29.75
Figure 14-4. — Nine-wheel, self-propelled rubber-tired roller.

stabilized soil. ballast, macadams, soil-cement, and asphaltic concrete.

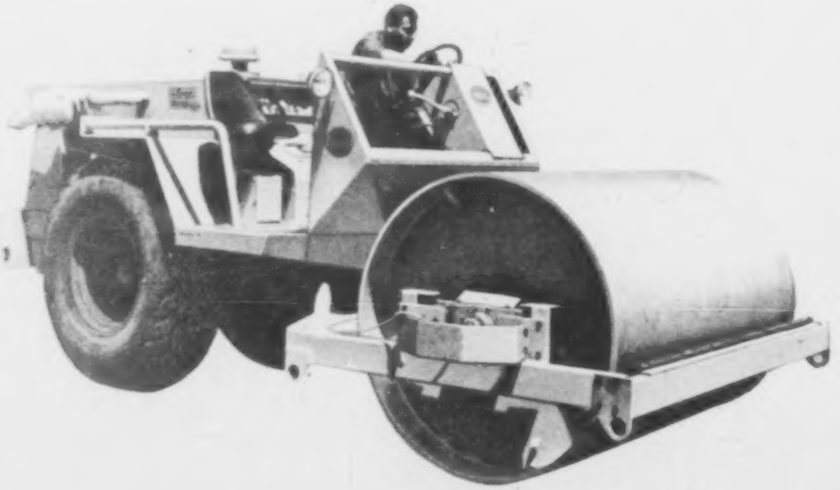
At 1800 to 2400 VPM (vibrations per minute), each kinetically charged thrust of the self-propelled vibratory roller releases a concentrated, penetrating force which closely compacts the material beneath it to greater densities than other types of power rollers commonly used in road and airfield construction.

TOWED ROLLERS

A TOWED roller, as the name implies, is one which is towed by a prime mover. The principal types of towed rollers are the TAMPING roller, the GRID roller, and the VIBRATORY roller.

TAMPING ROLLERS

A TAMPING roller contains one or more cylindrical DRUMS which revolve on a shaft mounted on a box-type towing frame. The towing frame is equipped with a towbar or tongue for hitching to the drawbar of the prime mover. Each drum is studded with projections called



29.73.2

Figure 14-5. — Vibratory roller, self-propelled.

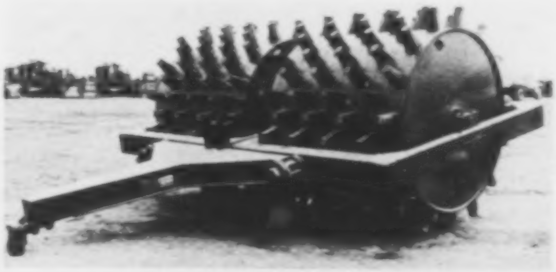


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Figure 14-6.—Tamping roller.

FEET, which usually run from 7 to 9-1/2 inches in length. Figure 14-6 shows a tamping roller with TAPERED feet. A tamping roller with straight-shank feet, each of which has an enlarged, off-center SOLE, is called a SHEEPSFOOT roller.

Tamping rollers are used mainly for compacting loose fill other than sand, gravel, or crushed stone. On the first pass, the feet will penetrate to their full length. As compaction increases with successive passes, the feet will gradually begin to "walk" themselves upward, until finally, when maximum compaction is attained, the feet will almost walk out of the fill with only a slight indentation.

Many tamping rollers can be ballasted for extra weight by filling the drum with sand or water. Some have containers for ballast mounted on the towing frame.

GRID ROLLERS

GRID rollers (figure 14-7) are used to break up old bituminous road surfaces which have been ripped; also the compact highway base courses, and to crush such materials as sandstone, soft limestone, and cinders. Grid rollers are mounted in towing frames similar to those on the towed rollers previously described. They are usually heavily ballasted with large blocks of concrete, or by sand containers mounted on the towing frame.

TOWED-TYPE VIBRATORY ROLLERS

Vibratory towed rollers (fig. 14-8) are used for effective vibratory compaction of soils in the construction of abutments, embankments, airfield runways, earthen dams, roads, and so forth. Vibratory towed rollers are high production units capable of compacting more materials faster and deeper with heavy impact vibrations in layers to a thickness of 30 inches up to 60 inches, depending on the class of material being compacted.

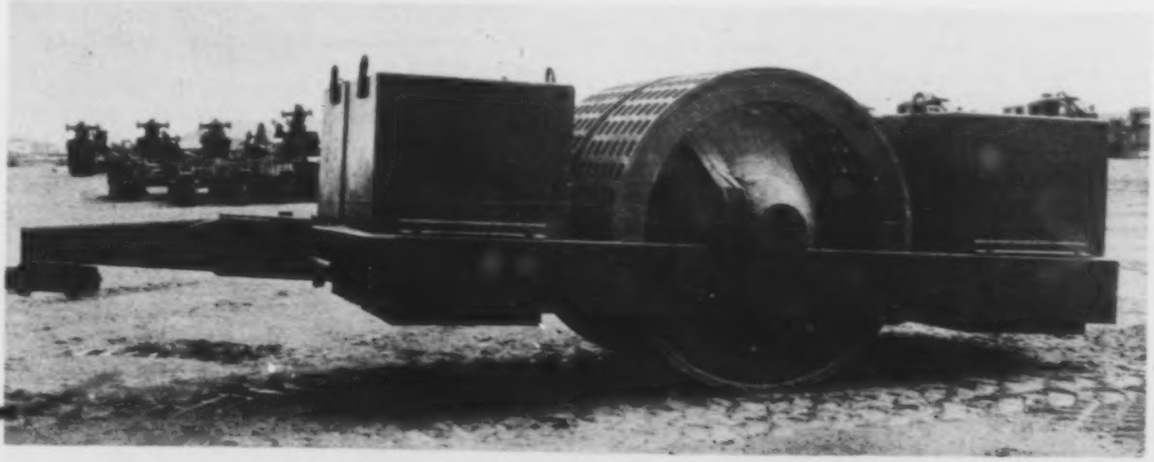

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Figure 14-7.—Grid roller.

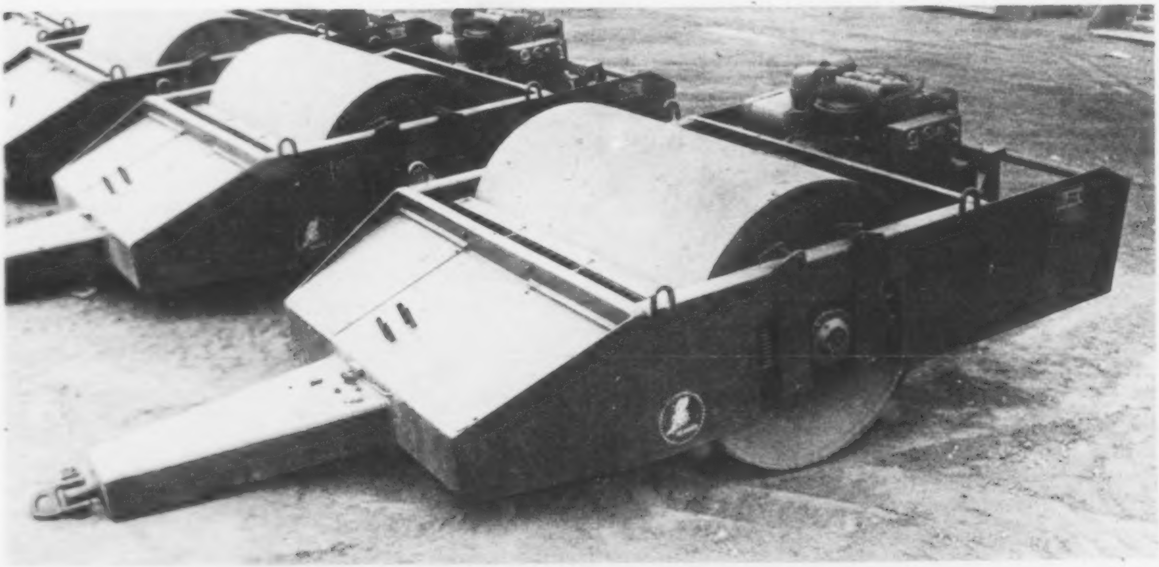

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Figure 14-8. — Vibratory roller, towed-type.

Much like the self-propelled vibratory roller, the towed-type vibratory roller induces vibrations which are adjustable from 1600 to 1900 VPM. The impact of the vibratory force is up to a compacting power of 100 tons.

The entire chassis frame of the vibratory roller is suspended so that the entire vibrating compaction force is concentrated through the compaction roll to the ground.

CAPABILITIES AND LIMITATIONS OF ROLLERS

There are too many variables involved to state that a certain type of roller should be used for each phase of compaction. But by knowing the characteristics, capabilities, and limitations of different types of rollers, an intelligent selection can be made for a given job.

Possibly the best way to discuss compaction is to approach it from the different stages of construction and the compaction equipment used in each stage.

EMBANKMENT CONSTRUCTION

The term "embankment," as used here, refers to that part of the raised structure below the depth of the subgrade material influenced by traffic loads and climate conditions. The purpose of densification is to prevent detrimental settlement and to aid in providing stable slopes. The materials normally used in this area are soil, soil-aggregate, or rock.

Sheepsfoot rollers which produce high unit pressures, and other types of rollers which produce heavy wheel loads and high unit pressures, make it possible to obtain desired densities at low moisture content. Pneumatic-tired rollers generally will handle thicker lifts than a sheepsfoot, so that if rocks or cobbles are present they usually can be incorporated into the fill. Fills or portions of fills subject to inundation or scour (washing away) should be compacted at near optimum moisture content to lower the permeability and offer a greater resistance to softening of the fill material.

SUBGRADE COMPACTION

The term "subgrade material" refers to soil at a depth which may affect structural design or how climate affects the soil.

Subgrade areas may be in depths up to 10 feet for pavement designed to carry heavy loads. Heavy pneumatic-tired rollers are perferred in such areas due to their compaction capabilities. Sheepsfoot rollers may be used to break up soft, over sized rock in subgrades and for compaction throughout the subgrade area. Another roller, steel-wheel or rubber-tired, will be required to dress up the surface of the final lift when using the sheepsfoot roller. This other roller can also be used to seal off the surface when rain is anticipated during construction. If the material in the subgrade area is sand, a vibratory-type compactor would be the most efficient item to use. In the absence of a vibratory-type compactor, a crawler-tractor with loosened tracks can be used to compact the sand; or a rubber-tired roller having low tire pressure may be used, but in this instance, the material must be compacted in shallow lifts, no greater than 2 to 4 inches in depth.

BASE COURSE COMPACTION

The base course provides the strength of pavements. When subgrade strength is low, the stresses created by surface loads must be reduced to a low value, and a substantially thick base course is needed. Where the subgrade strength is high, a medium thickness will provide adequate distribution. Since the stresses in the base course are always higher than in the subgrade, the base course must have a high strength. To meet this requirement a mixture of uniformly graded granular materials generally is needed, with a full range of particles from coarse to fines, and a top size of 1.5 to 2 inches. Sheepsfoot rollers ARE NOT USED in this area. Best results are obtained from rubber-tired rollers which compact, knead, and confine these granular particles. Steel-wheel rollers can be used but they tend to displace the material laterally and are slow in operation. Steel-wheel rollers are efficiently used to dress off the wheel ruts of the pneumatic roller on the finished surface of the base course.

CONTROLLING LOOSE LIFT DEPTH

Material must be placed in depth controlled lifts, taking into consideration the maximum size of the aggregate and the shrinkage which will result from compaction. Normally, for each unit of depth of compacted lift, 1.15 to 1.25 units of loose lift are required. However, the shrinkage factor should be checked, using a test strip.

OPERATION OF POWER ROLLERS

The safe and efficient use of power rollers requires skill and alertness on the part of the operator. To develop the skill required for safe and efficient operation of rollers, you should not only become familiar with their make-up, but also understand their capabilities and limitations.

Let's take a look at one particular model of a power roller to familiarize you with its instruments and controls, as well as operational capabilities. The information given is on the Galion ROLL-O-MATIC, 2-axle tandem power roller, and applies ONLY to that machine. The Galion ROLL-O-MATIC is one of several types of power rollers used by the SEABEES.

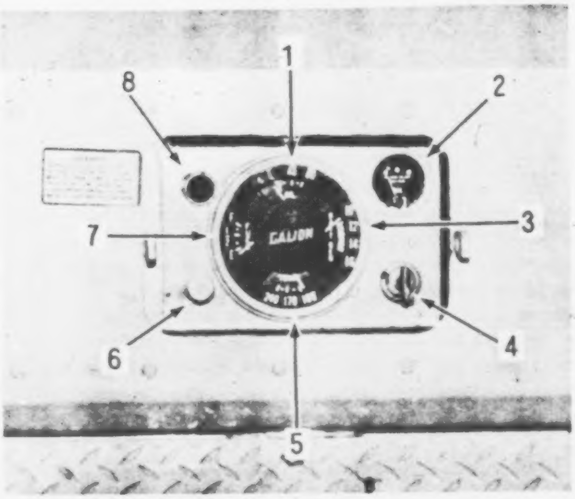
The location of various instruments on the Galion ROLL-O-MATIC roller is indicated in figure 14-9. Since various instruments of these types have been discussed in previous chapters of this manual, they are not discussed in this chapter.

Figure 14-10 shows the operating controls of the Galion ROLL-O-MATIC roller. A brief discussion of these controls is given below.

The STEERING LEVER (1) will turn the roller in the direction it is moved. Push the GOVERNOR CONTROL LEVER (2) forward to increase speed and pull it back to slow down the roller. The lever is spring-loaded with a friction disk and will remain in the position selected. Turning the ELECTRIC WATER PUMP SWITCH (3) to the "ON" position will run the pump and furnish water under pressure to the roll moistening bars. Turning the switch to the "OFF" position, will stop the pump.

The roller is equipped with dual FORWARD and REVERSE CLUTCH LEVERS (4) that allow the roller to travel in the direction the levers are moved. When the levers are in the center position the roller is in neutral. Be sure to operate the levers fully for complete engagement of the clutch (snap over center).

When securing the roller, engage the independent external contracting parking brake



1. Oil pressure gage, engine
2. Glow plug meter (diesel power)
3. Voltmeter
4. Key switch, starting
5. Temperature gage, engine
6. Choke cable (gasoline power)
   Engine stop cable (diesel power)
7. Fuel gage
8. Glow plug switch (diesel power)

115.337
Figure 14-9.—Instrument panel, Galion 2-axle tandem roller.

by applying the BRAKE LEVER (5). To make a minor adjustment to the parking brake, turn the knurled knob in a counterclockwise direction. When the handle is up, the brake is "ON" and when down, it is "OFF."

The proper way to brake the roller is to press down the SERVICE BRAKE PEDAL (6). The pedal can be locked down, if desired, by engaging the ratchet and pawl. To unlock, push down on the pedal and the pawl will release.

Before engaging the forward and reverse clutch levers, stop the roller and select the desired speed by shifting the GEAR SHIFT CONTROL LEVER (7) either into high or low range speed. It may be necessary to slip a clutch slightly to bring the shifting in alignment during this shift.

There are certain steps you must take in starting the roller. After making the usual prestart checks of the engine crankcase oil level, the transmission oil level, the fuel supply, the battery water level, and the coolant, be sure the forward and reverse clutch lever is in neutral or center position and the parking brake is on (up). Move the governor control lever approximately one-third of the travel to the front.

Be sure the fuel pump control button (diesel) is in all the way. Depress the glow plug switch for a minimum of from 30 to 45 seconds for the glow plugs to preheat. Now turn the key switch clockwise to operate the cranking motor. When the diesel engine starts, allow the governor control lever to remain in the starting position until the engine runs smoothly. Then move the governor control lever either in high or low range speed depending upon conditions. Release the parking brake. Remember, do not shift gears while the clutch is in full engagement, and never attempt to shift gears when your roller is on a hill or grade without first bringing your roller to a complete stop. Never attempt to operate a roller without the forward or reverse clutch lever being snapped in over center position.

If the roller is to be parked or stopped for any length of time, as when waiting on material or during a lunch break, and the engine is allowed to run, the following procedures must be followed to ensure adequate transmission lubrication:

1. Shift the gear shift control lever to the neutral position.
2. Engage the forward and reverse clutch levers either into the forward or reverse position.

In addition to the controls and instruments discussed, the roller is equipped with sprinkler equipment for the compression and steering rolls. When rolling hot mix, a very tacky surface or patching material, sprinkling equipment should be used.

Be sure the sprinkler tanks are filled, start the roller engine, and turn the sprinkler switch to the "ON" position. Then depress the restart lever through the floor plate (fig. 14-11) and hold until water flows on the rolls. (For even and regulated distribution of water, cocoa sprinkler mats attached to each roll (fig. 14-12) control this distribution.) When the desired wetting

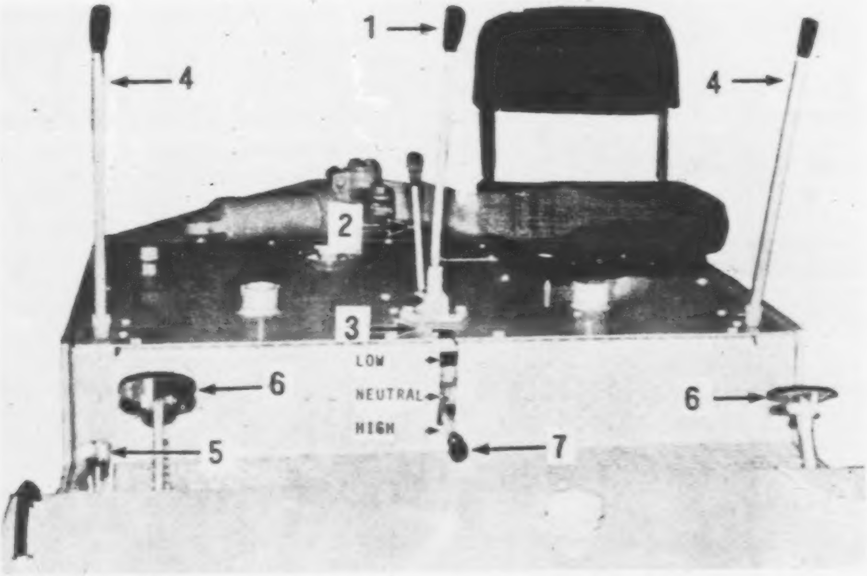


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Figure 14-10.—Operating controls, Galion 2-axle tandem roller.

of the rolls is accomplished, release the re-start lever and turn the sprinkler switch to "OFF" position.

If long intervals of time occur between sprinkling, the pump can possibly lose prime and the re-start lever may have to be operated again to make the sprinkler system operative. Should the tanks empty or the pump lose its prime, the vacuum switch will open an electric circuit and stop the pump.

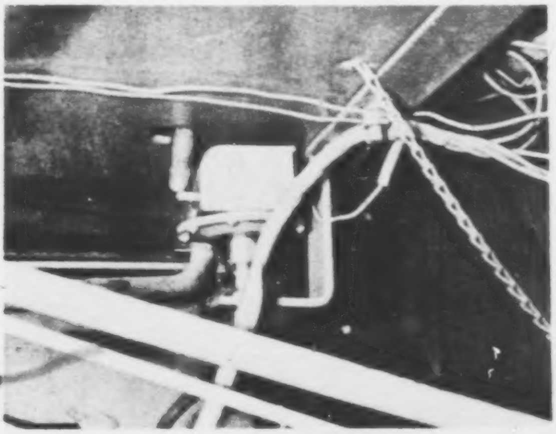

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Figure 14-11.—Sprinkler re-start lever.

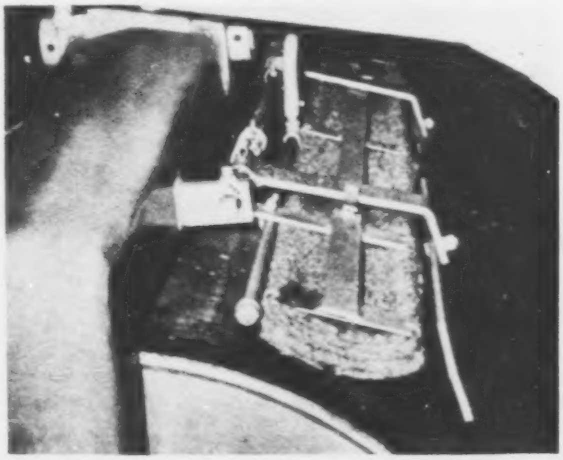

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Figure 14-12.—Sprinkler mat.

WORKING WITH ROLLERS

Decisions concerning the time when rolling will begin, the methods to be applied, the number of passes to be made, the type and weight of roller to be used, and the like, will be made for you by your superiors. You should know, however, the main considerations which guide some of these decisions. The following operational techniques are those which are applied under ordinary circumstances. They may always be changed or modified by your superiors.

Depth of Loose Material

The depth of loose material of any type which can be compacted effectively by rollers of different types in a given number of passes is usually determined in the field by tests. The following information is intended to serve as a general guide only.

For a tamping roller the depth of loose material should not exceed the length of a foot on the roller, which is usually from 7 to 9-1/2 inches. Navy specs, however, limit loose material to 6 inches. Six to 12 passes are usually required to obtain adequate compaction in soil which is neither too wet nor too dry. When the number of passes is not specified, the usual practice is to repeat passes until the feet have "walked" themselves almost entirely out of the ground.

For 3-wheel rollers, tandem rollers, 3-axle tandem rollers, and 9-wheel, self-propelled rubber-tired rollers, the depth of loose soil should not exceed 6 inches and the depth of bituminous material should not exceed 4 inches.

The 11.5-ton vibratory towed roller, with up to 1600 impacts per minute, compacts lift thickness up to 40-inches depending upon conditions.

Number of Passes

The number of passes required for a given roller to compact a given type of soil effectively is also determined in the field by tests. The following information is intended to serve as a general guide only.

For soil with optimum moisture content (neither too wet nor too dry), a tamping roller with 9-inch feet should compact a 9-inch layer of soil to 95 percent compaction in from 10 to 12 passes. Percent compaction is percent of modified density according to a scale devised by the American Association of Highway Officials. Specifications generally stipulate a certain percentage of compaction in accordance with this scale.

In soil of optimum moisture content, a 3-wheel, 10-ton roller should compact a 4-inch layer of soil to 75 percent compaction in from 3 to 6 passes. Initial compaction (also called BREAKDOWN ROLLING) of a hot-laid bituminous mix should be obtained in a single pass. Normal operating speed for a 3-wheel, 10-ton roller is from 2 to 3 mph.

In soil of optimum moisture content, a 10-ton 2-axle tandem roller should compact a 4-inch layer of loose soil to 75 percent compaction in 2 to 4 passes. Cold-laid bituminous mixes up to 3 inches in depth should be compacted in 3 to 5 passes. For finish rolling of hot-laid bituminous mix, 3 to 6 passes should be enough.

In soil of optimum moisture content, a 13-wheel, 10-ton rubber-tired roller should compact a 4-inch layer of loose soil to 95 percent compaction in 2 to 4 passes. It should compact a 3-inch layer of cold-laid bituminous mix in from 3 to 5 passes. Normal operating speed for this rig is 10 to 15 mph.

In soil of optimum moisture content, a single-unit, towed-type vibratory compactor should compact a 30-inch layer or well-graded sand to 90 percent compaction in 5 to 6 passes.

Overlapping

To ensure thorough coverage of a rolled surface, each pass should overlap the preceding pass by at least 1 foot. For deep, loose material, such as loose fill or gravel, the overlap should be wider.

Crowns and Banked Turns

In compacting crowned surfaces or banked turns on a highway, work up the slope. For example, on a crowned highway subgrade, make the first pass along the shoulder on one side or the other, then work up to the centerline in successive passes. Then pull out to the shoulder on the other side and again work up to the centerline. On a banked turn, start on the low shoulder and work up to the high one.

Turning

Whenever possible, avoid turning on a compacted surface. If turning on such a surface is unavoidable, turn very gradually and at low speed. A sudden turn at high speed will scuff a surface badly. A sharply turned guide roll may gouge a groove in a surface.

Estimating Work Output of Rollers

The quantity of fill material which can be compacted per hour by a particular type of roller depends on the type of soil, moisture content, thickness of the layer, and speed of the roller. The quantity of loose material that rollers can compact can be estimated by formulas, as follows:

$$\text{Cubic yards per hour} = \frac{60 \times S \times W \times E \times D}{N \times 27}$$

$$\text{Square yards per hour} = \frac{60 \times S \times W \times E}{N \times 9}$$

where:

S = speed of travel in feet per minute
W = effective width of roller in feet
E = efficiency factor
D = depth of loose layer in feet
N = number of passes with roller.

NOTE: Soil conversion factor (f) from table 8-1, chapter 8, is applied to obtain answer in "in-place" or in "compacted" cubic yards.

ROLLER OPERATION

The primary purpose of rolling is to obtain maximum compaction in order to develop stability in road, highway, building, and airfield subgrades and flexible paving materials.

Let's look at some uses of a roller when working with bituminous materials.

On cold-type mixes using cutback asphalt and light tars, it is sometimes necessary to hold back rolling from 1 to 48 hours, while on hot mixes the roller should be placed on the mat as soon as it will support the roller.

Normally, 250 to 270 degrees is considered the right temperature for rolling hot mixes. Displacement of the material indicates more curing time should precede the rolling.

All rolling on cutbacks and similar materials must be staggered in order to compact the materials at various stages in the curing and hardening process and to avoid the excessive kneading action caused by continuous rolling.

Both premature and excessive rolling are to be avoided, and rolling must be regulated to the hardening of the bitumen. In cutbacks, this depends primarily on the evaporation of the volatiles and is affected by the weather, the amount of cutback used, and the amount of aeration during the mixing.

The initial or breakdown pass with the roller should be as soon as possible to roll the mixture without shoving the mat or having the mix pick up on the roller wheels.

If the mix is too hot to roll, cracking will be evident. Cracking is caused by the surface of the mixture cooling much more rapidly than the mass below, giving differential movement under the roller.

The final or finished rolling needed to leave a smooth finished surface should not be started until the mix has cooled sufficiently so that few or no roller marks are left in the mat. A rule of thumb is do not finish rolling until you can place your hand on the mat.

In general, the lightest roller that should be put on an asphaltic mixture is around 5 tons and this is only in the case of mixes that have borderline or low stability.

Most effective rolling can be done with an 8- to 10-ton roller. In some cases, especially where high stability mixes having large proportions of crushed material are involved, it is wise to use a 10- to 15-ton roller for the breakdown pass, with the finish rolling being done with either the heavy roller or a lighter one.

In the case of borderline stability mixes, only that roller which can be adequately supported by the mix should be used.

It should be kept in mind that for street and highway construction, the primary purpose of rolling is to set the mix down and to leave a smooth surface. The ultimate density will be achieved by the traffic.

The exception to the above is in cases where traffic is light and the weather is cool. In this case, maximum density must be achieved in the construction phase.

It should be noted that by over rolling the mat, the compaction and bond that was achieved under the breakdown compaction may be destroyed.

Over rolling may be indicated by the mix mushing or shoving under the roller after the initial rolling. This is also an indication that too heavy a roller is being used, or the mix is too hot, or both.

Rolling direction is very important, and the following fundamental points should be observed no matter what rolling procedure is employed.

1. With steel rollers, the rolling operation should always progress with the drive roll forward in the direction of the paving. It is important that this procedure be followed during the breakdown pass or initial rolling of an asphaltic mat. It is also important later on in rolling operations.

2. The greatest percentage of compaction that occurs during the construction phase is on the breakdown pass. One of the main reasons that the breakdown should be done with the drive roll, rather than with the tiller roll, is that there is more direct vertical load applied by this roll than with the tiller roll.

3. The turning force tends to tuck material under the tiller roll. It is for this reason that there is less tendency for the mix to mush or shove forward under the roller when the drive roll is used ahead of the tiller roller.

4. The direction of the roller is reversed at the end of a pass, then the tiller roll is on the compacted area and its movement in changing direction will do less to displace the mix. There are two exceptions to this rolling technique: (1) when there are high superelevations being constructed, and (2) when the grade on which the pavement is being placed is excessive. When high grades are encountered, the drive roll of the roller will chatter on the mat, causing displacement of the mix and a very rough surface. In these cases, the roller must be turned around to allow the tiller roll to partially compact the material in order that the drive roll can proceed over it.

5. Another fundamental to be observed in rolling is to start the rolling operation from the low side of the spread and progress toward the high side.

6. When the asphaltic mixes are hot they tend to move toward the low side of the spread under the action of the roller.

7. In matching lanes, start the rolling pattern from the low side after compaction of the fresh mix has been made at the longitudinal joint (using only from 6 to 8 inches of the roll width).

8. A crowned road is rolled by starting at the outside edge and working toward the center of the road. Repeat this pattern on the opposite side of the road.

9. Banked or superelevated curves are rolled from the inner edge of the outside edge of the road.

When rolling joints, the following points should be kept in mind:

1. Lengthwise and transverse joints require special attention. Transverse joints are kept to a minimum. The roller is kept at least 8 inches back from the edge until the next strip is laid. Then the joint is rolled as soon as possible after the hot material has been laid.

2. In paving long strips requiring cold joints, the entire strip is rolled, but the roller is not permitted to project over the edge of the strip.

Finish rolling is completed with the pneumatic roller. These rollers tend to knit together and seal the surface of the mat. The finish rolling should follow behind the secondary rolling as soon as possible to obtain the best finish.

ROLLER CARE AND MAINTENANCE

As with most equipment, the operator's and maintenance manual supplied by the equipment manufacturer contains the complete instructions for care and maintenance (including lubrication) of the roller. Here are a few general principles of operational maintenance which all roller operators should follow:

1. Check the roller daily when in use for loose nuts and bolts and for worn parts.

2. Check the fuel, lube oil, battery, and coolant levels at the start of roller operations.

3. Fill the fuel tank at the end of each work day.

4. Keep the roller free of dirt, mud, and asphalt.
5. When you leave the roller for an extended period, shift the range lever to neutral and engage either the forward or reverse clutch.

Correct lubrication of any machine is of prime importance in prolonging its useful life. Fuels, oils, and greases should be of a good quality and kept free of dirt, water, and other foreign matter.

All level plugs or pressure grease fittings should be cleaned prior to opening for level check or prior to pressure gun installation.

A special effort should be made to have the proper weights of oils and greases on hand for prevailing operating temperatures.

When draining the gear housing cases or the engine crankcase, care should be taken to drain when the oil is warm. The reason is that the oil is lighter and therefore drains more completely than when it is cold. The best time to drain oils and grease is at the end of the day's run. In this way, any dirt in the oil will be drained off while it is still in suspension and before it has a chance to settle.

REMEMBER ! REFER TO THE MANUFACTURER'S LUBRICATION CHARTS AND INSTRUCTIONS.

ROLLER SAFETY

Many of the safety precautions previously listed for dozers, scrapers, and graders also apply to rollers. A roller is easier to overturn than most other equipment. Rolling on a side slope should always be done at right angles or diagonally rather than parrallel to the slope. Steer carefully when rolling a shoulder to avoid capsizing into the ditch, and never bring a roller near the edge of a cut.

The tendency of a power roller to overturn easily has caused accidents when towing. If the tow wire from the towing vehicle is attached to a high point on the roller (it is usually attached to the gooseneck or walking beam), great care must be exercised when the towing vehicle makes a turn. As the tow wire comes close to making a right angle with the fore-and-aft axis of the roller, the roller has a strong tendency to be pulled over by the strain on the wire.

When moving the roller from one jobsite to another, care must be taken to secure the roller properly to the trailer. Tie down holes are usually provided at convenient locations within the roller frame. Do not secure the roller in place by chaining the steering roll. If the roller is to be transported long distances or moved over rough roads, added blocking of the steering roll on the sides will be needed. Do not block in any other manner. Failure to observe these instructions could result in serious damage to the steering yoke and kingpin.

DITCHERS

A DITCHER is a mechanical excavator which, despite its name, is seldom used for digging the ordinary type of roadside drainage ditch. Ditchers are used most frequently for digging trenches for pipelines and utility lines to handle water, fuel, electric cable, sewage, and the like. In some cases, you may use a ditcher to cut a building foundation. For trenching jobs calling for higher production, heavy duty ditchers are used.

TYPES OF DITCHERS

There are three types of ditchers: the VERTICal boom type, the WHEEL type, and the LADDER type.

On the vertical boom ditcher (fig. 14-13) the excavating is done by a number of digging buckets. The buckets are mounted on an endless chain which travels around a long steel boom. When the rig is digging, the boom is set vertically in the ground. It can be raised and lowered to control the depth of the cut and to "jump" such obstacles as buried pipes, rocks, and electric cables. As each loaded bucket rides over the top of the boom, it dumps its load on a belt-type spoil conveyor, which carries the excavated material out to one side and drops it in a windrow as the ditcher proceeds along the line of the trench.

On the wheel ditcher (fig. 14-14) the digging buckets are mounted on a large wheel; the wheel is attached to a frame-type horizontal boom that can be raised and lowered. Like the vertical boom ditcher, the wheel ditcher is equipped with a spoil conveyor for carrying the excavated material out to one side.

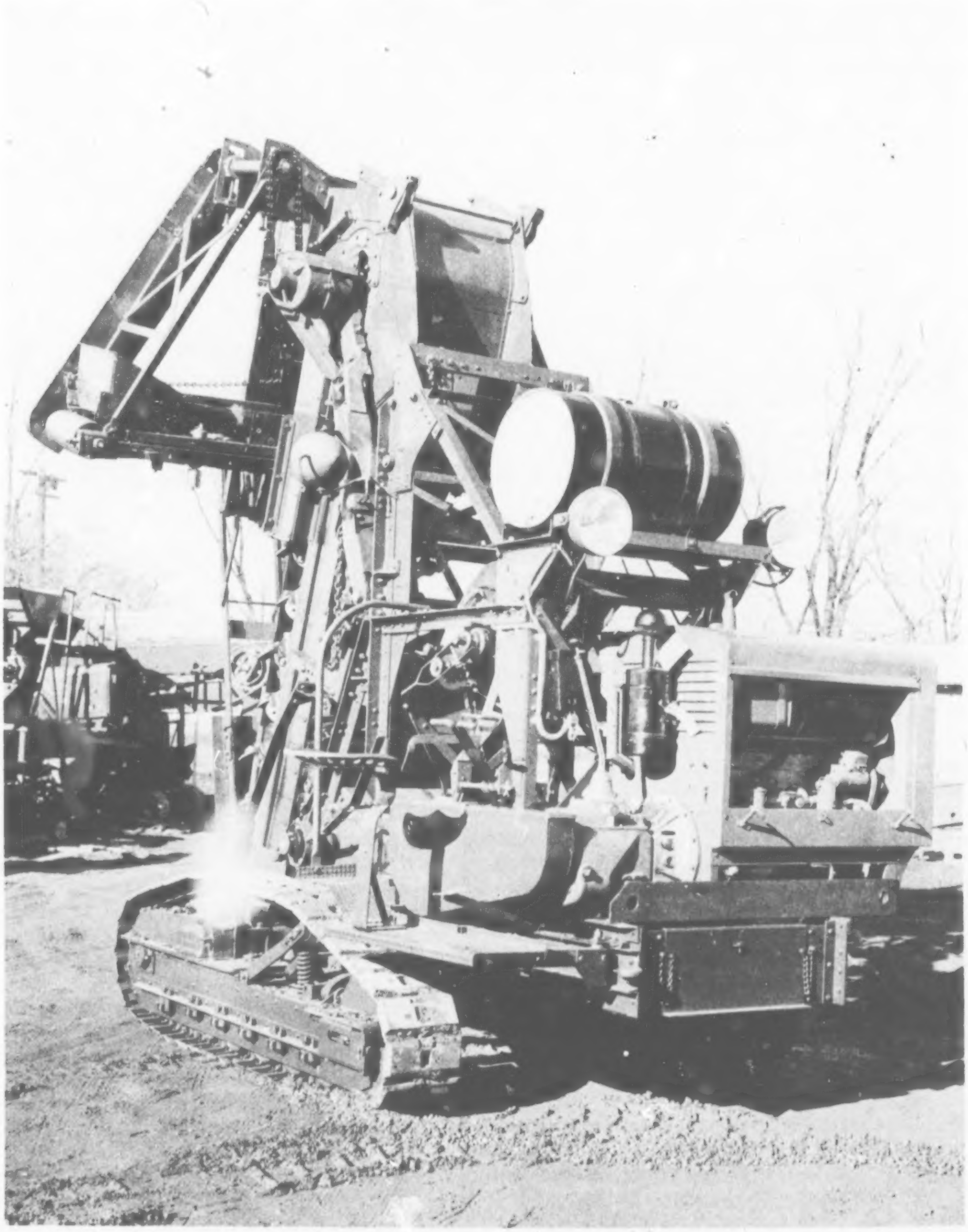

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Figure 14-13.—Vertical boom ditcher, Barber-Green model 44C.

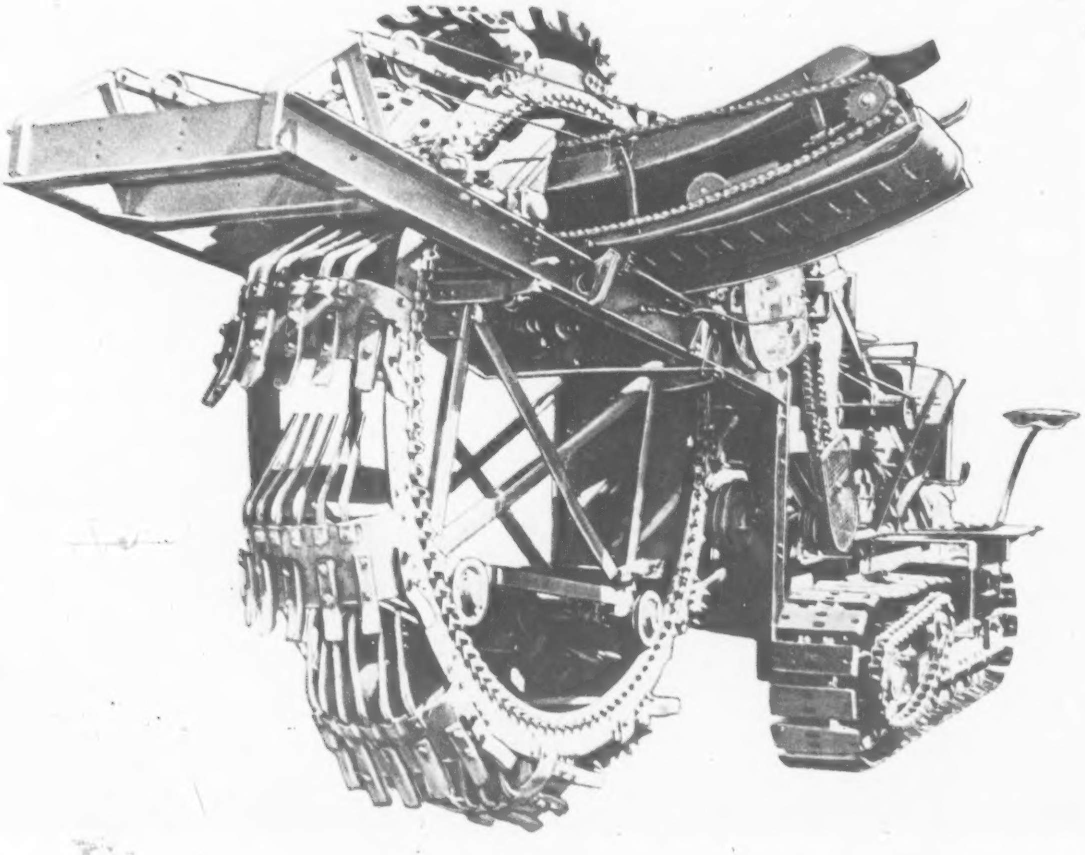

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Figure 14-14. — Wheel ditcher.

The ladder-type ditcher (fig. 14-15) is similar to the vertical-type ditcher except that the boom cannot be brought closer than about 35 degrees to the vertical. With the ladder-type ditcher, excavating is done by buckets attached to the bucket line chain; the chain travels on the drive sprockets on the boom assembly. Like the vertical boom-type ditcher and wheel-type ditcher, the ladder-type ditcher is equipped with a spoil conveyor for carrying the excavated material out to one side.

Advantages of the vertical boom-type ditcher are: (1) it digs straight down, so as to leave no ramps at the ends of trenches or around buried objects such as pipes; and (2) it can easily change courses to dig around sharp curves or angles. The ladder-type ditcher, like the wheel-type ditcher, leaves ramps which must be removed by hand, at trench ends and around buried objects; the radius of a curve which may be cut is governed primarily by the density of the soil being excavated. The turn should be made cautiously in a slow digging speed and only up to the point where the boom starts binding between the trench walls.

The chief advantage of the wheel-type ditcher is that in material of a given density, it will dig faster than the vertical-type ditcher. Consequently, the wheel ditcher is preferable to the vertical boom-type ditcher for cross-country digging where speed is important.

115.341

Figure 14-15.—Ladder ditcher, Parsons model 724L.

A ditcher may be either crawler-mounted or wheel-mounted, the crawler-mounted being the most commonly used.

DITCHER CAPABILITIES AND LIMITATIONS

A ditcher may be used to dig earth material ranging in texture from soft to hard. As the material being excavated increases in hardness, the production rate obviously decreases. A trial run should be made at the site to estimate the ditcher's output.

The ditcher is capable of digging only perpendicular to the slope of the land surface. The crawler ditcher is capable of maintaining a given gradeline from a stringline 49-inches right of centerline set at the desired slope. A wheel-mounted ditcher, however, can only maintain the grade ground surface. Thus, when preparing the site, the ground surface should be leveled, and for the wheel-mounted ditcher, brought to grade by using a grader.

Table 14-1 gives maximum trenching rates for various classes of soils in feet per minute. Over wide areas, ideal trenching conditions seldom exist. Delays in providing lines and grades slow production rates.

OPERATION OF DITCHERS

To acquaint you with the controls, as well as the operational capabilities, of the Parsons model 724L, ladder-type ditcher, the following information is given and applies ONLY to that machine. This information will give you some idea of how one type of ditcher used by the SEABEES is controlled and operated.

Table 14-1.—Crawler Ditcher Maximum Trenching Rates

Production, in feet per minute

Depth of trench	Dry-to-moist sand	Soft, dry clay	Most clay	Hard clay and gravel	Sticky clay
1 ft 6 in.	32	28	26	22	16
2 ft	25	22	20	17	12
2 ft 6 in.	20	18	16	14	10
3 ft	16	15	13	11	8
3 ft 6 in.	14	13	11	10	7
4 ft	12	11	10	8	6
4 ft 6 in.	11	10	9	7	5
5 ft	10	9	8	6	4

115.483

DITCHER CONTROLS

The operating controls on the Parsons model 724L ditcher are shown in figure 14-16. The operating lever bank is made up of 11 operating levers. The purpose of each lever is indicated below.

The foot-operated ENGINE CLUTCH CONTROL PEDAL (1) is used to engage or disengage all ditcher machinery from the engine.

The ENGINE TRANSMISSION CONTROL LEVER (2) is used to select the four speeds in traveling the machine in hi-traction and for selecting bucket line speeds and crawler speeds in conjunction with the LO-traction transmission when digging with the machine.

To select crawler speeds when digging, the LO-TRACTION TRANSMISSION CONTROL LEVER (3) is used.

When the RIGHT-HAND STEERING CLUTCH LEVER (4) is pulled towards you, a brake is applied which turns the ditcher to the right.

By pushing the EXCAVATOR CLUTCH LEVER (5) away from you, a clutch is engaged which transmits power to the digging boom.

When the LEFT-HAND STEERING CLUTCH LEVER (6) is pulled towards you, a brake is applied which turns the ditcher to the left.

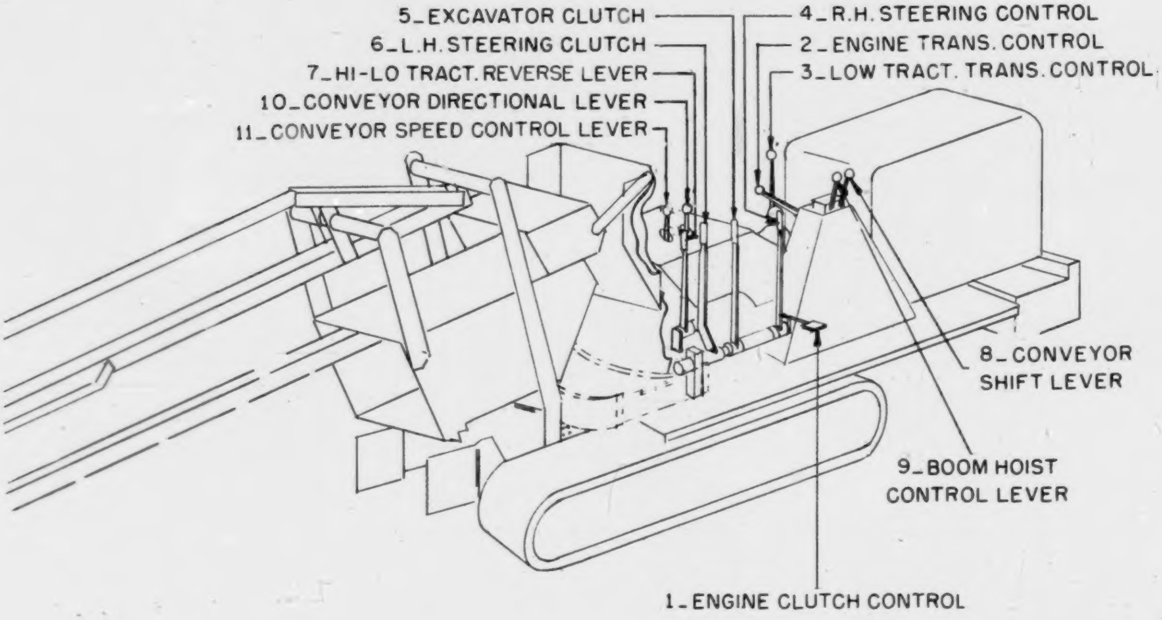
The HI-LO TRACTION REVERSE LEVER (7) is used for selecting high traction reverse or forward for traveling the ditcher and LO-traction for digging.

The spoil conveyor which carries excavated material is moved through the ditcher main frame by engaging the CONVEYOR SHIFT LEVER (8).

To raise or lower the ditcher digging boom, engage the BOOM HOIST CONTROL LEVER (9).

Engaging the CONVEYOR DIRECTIONAL LEVER (10) allows the spoil material to flow on one side or the other. To discharge the material to the left side of the ditcher, push the lever away from you. To discharge the material to the right side of the ditcher, pull the lever towards you. Neutral is located in the center position.

The CONVEYOR SPEED CONTROL LEVER (11) governs the speed of the conveyor belt. When first or low speed is required, pull the control lever towards you to its maximum travel.


5_EXCAVATOR CLUTCH
6_L.H. STEERING CLUTCH
7_HI-LO TRACT. REVERSE LEVER
10_CONVEYOR DIRECTIONAL LEVER
11_CONVEYOR SPEED CONTROL LEVER
4_R.H. STEERING CONTROL
2_ENGINE TRANS. CONTROL
3_LOW TRACT. TRANS. CONTROL
8_CONVEYOR SHIFT LEVER
9_BOOM HOIST CONTROL LEVER
1_ENGINE CLUTCH CONTROL

115.342

Figure 14-16.—Operating levers, Parsons model 724L.

When second or intermediate speed is desired, push the control lever away from you to the center position. When third or high speed is required, push the control lever away from you to its maximum length of travel.

DITCHER OPERATION

The following procedures should be followed in the operation of the Parsons, model 724L ditcher.

After checking to make sure that the engine transmission control lever (see (2) fig. 14-16) is in neutral position, start the engine. Depress the engine clutch control pedal (1), and select the desired forward speed with lever (2). Pull the hi-lo traction reverse lever (7) towards you, toeing the engine clutch control pedal (1) until the high traction clutch is engaged. Push the left- and right-hand steering clutch levers (4) and (6) away from you to engage the steering clutches. Release the engine clutch control pedal (1) and you will travel forward in a straight line.

To turn the ditcher to the right (direction of the operator's side of the ditcher), pull the right-hand steering clutch lever (4) towards you; this action disengages the right-hand clutch and applies the brake on the right-hand steering clutch housing.

To turn the ditcher to the left (direction opposite the operator's side of the ditcher), pull the left-hand steering clutch lever (6) towards you. This disengages the left-hand clutch and applies the brake on the left-hand steering clutch housing. The ditcher can be traveled in a straight line by engaging both steering clutches.

When the job location has been reached, you can back your ditcher into position to dig by depressing the engine clutch control pedal (1) and by pushing the hi-lo traction reverse lever (7) to the center position and raising up on the lever to engage the stop shifter shaft. Pull back to engage hi-reverse, toeing the engine clutch control pedal (1), and the machine will back up. By using steering clutch levers (4) and (6) for turning, you can maneuver the ditcher to the exact position for starting to trench.

Be sure the ditcher is in LO-traction before starting a trench. When making LO-traction selection, the engine should be running at idle speed. Pull steering clutch levers (4) and (6) towards you until the brakes are locked in position. With the engine clutch control pedal (1) depressed, select the desired engine speed with lever (2). Release the engine clutch and select the digging speed in LO-traction transmission with lever (3). Push hi-lo traction reverse lever (7) away from you, applying a slight steady pressure on the lever until the LO-traction clutch is engaged.

To start the bucket line, push the excavator drive clutch lever (5) away from you; this action engages the excavator clutch. Before lowering the boom to the ground, you should select the correct digging speed with lever (2). This speed will depend on the soil conditions. Soil with an average amount of moisture, or dry soils, may be trenched faster than hard or rocky soils. While digging wet sticky soils, a high bucket line speed should be used to prevent the soil from adhering to the buckets.

When ready to discharge spoil, start the conveyor belt by engaging the conveyor directional control lever (10). To discharge spoil to the operator's side of the ditcher, pull the lever towards you. To discharge to the opposite side, push the lever away from you. The speed of the conveyor belt may be selected by moving the conveyor speed control lever (11) to the desired speed position.

The conveyor is shifted through the ditcher frame hydraulically. By pulling the lever towards you, the conveyor will move to the right (or operator's side) of the ditcher. Push the lever away from you to shift the conveyor to the left side of the ditcher (away from the operator's side).

The ditcher is equipped with a floating crumber that may be set-in with a minimum of forward movement. Move the ditcher to the starting point. Lower the bucket line to the ground. Lock the steering brakes, engage the excavator clutch, shift the main gear case lever into LO-traction; select the bucket line speed in the engine transmission, start the conveyor belt, and select the crawler speed in the LO-traction transmission. Release the engine clutch pedal to start digging. Lower the boom, being careful not to crowd it, as it will jerk the ditcher to the rear. As the boom is lowered, the floating crumber will move up and forward. If the shoe of the crumber binds on the end of the trench, engage the steering clutches to move forward until the crumber shoe is free; then, continue to lower the boom to the desired depth.

If you wish to slow down or speed up the LO-traction drive during digging, disengage steering clutch levers (4) and (6). Then, select the crawler speed desired by engaging the LO-traction transmission lever (3). It is not necessary to stop the bucket line or conveyor when doing this.

There are 16 digging speeds available through the use of four speeds in the LO-traction transmission control lever (3), in combination with four forward speeds in the engine transmission control lever (2). CAUTION: Stop the bucket line and conveyor when shifting lever (2).

The radius of a curve which may be cut while excavating a trench with the ditcher is governed primarily by the density of the soil being excavated. In sandy or loose soil, the radius can be much less than in hard, compacted and rocky soil. The turn for the vertical-type ditcher is similar to that of the wheel-type ditcher in that it should be made cautiously in a slow digging speed and only up to the point where the boom starts binding between the trench walls.

When hoisting the boom out of the ground, pull lever (9) towards you, disengage both steering clutch levers (4) and (6), and let the bucket line and conveyor run to clear the material. The boom should be raised out of the ground when the ditcher is to be stopped for a period of time to prevent any damage from cave-in or freezing.

When the engine clutch control pedal (1) is disengaged, all ditcher machinery stops.

For safety, load and unload your ditcher in LO-traction.

DITCHER CARE AND MAINTENANCE

For complete instructions on the care and maintenance of a given ditcher, refer to the manufacturer's manual. Some of the daily checks to be performed by the operator follow:

1. Look beneath ditcher for signs of oil, fuel, or coolant leaks.
2. Clean the digging boom, crawler tracks, and other moving parts.
3. Check for worn or missing bucket teeth.
4. Check for broken or missing bolts, keys, and other types of fasteners.

5. Before putting ditcher into operation, test all clutches and brakes.

6. After the engine has idled, check each power operation by running at a slow speed. Listen for unusual sounds.

7. Check instrument panel to see that all gages are operating properly.

8. Under freezing conditions, turn the digging boom and crawler tracks very slowly to be sure that they are not frozen.

9. Check oil level in engine crankcase and all transmissions.

10. Check coolant level in radiator. If antifreeze is being used, test for proper strength.

By following the lubricating charts in the operator's manual, ditcher operators can perform the required lubrication. The ditcher must be lubricated every 2 miles when traveling.

DITCHER SAFETY

Standard safety precautions for ditchers are as follows:

1. Don't leave the operator's seat unless you have stopped the ditcher.

2. Don't engage the engine clutch too fast. Let it engage gradually to prevent damage to the gear cases and other moving parts.

3. Don't fill the fuel tank with the engine running.

4. Don't allow bolts and keys to come loose. Be alert for unusual sounds or odors. These are danger signs and should be investigated to prevent down time.

5. Don't let anyone work or stand close to the digging boom. In case of a cave-in, they might be pulled into the boom or other moving parts.

6. NEVER attempt to remove an object from the conveyor belt while the conveyor is running.

7. When the ditcher is secured for any length of time, the bucket line must always be raised clear of the trench.

8. Ditchers in operation must be well flagged by day and adequately equipped with lights at night.

CHAPTER 15

AIR COMPRESSORS, EARTH AUGERS, AND ROCK DRILLS

In the Naval Construction Force compressed air is used to inflate tires, spray paint, clean equipment, furnish air for underwater divers, and provide a source of power for drilling equipment.

When the need arises for soil testing, placing deep footings, setting fence posts, utility poles, and explosive charges, the power earth auger may be used to accomplish these tasks. Earth augers are primarilly earth drills, but can also be adapted to penetrate soft to medium rock such as shale, soft limestone, and sandstone.

Hand-held rock drills are used primarily for drilling holes in rock; however, they can also be used for various other purposes in demolition work.

The SEABEES use various makes and models of air compressors and power earth augers. General information on starting, operating, and maintaining air compressors and power earth augers is given in this chapter. Also included is information on the principles of operating portable rotary drills and crawler-mounted rock drills. Safety precautions to be observed when working with or near drilling, blasting, and driving equipment used in quarry operations are also noted throughout the chapter.

AIR COMPRESSORS

A compressor is a machine for compressing air from an initial intake pressure to a higher exhaust pressure through reduction in volume. A compressor consists of a driving unit, a compressor unit, and accessory equipment. The driving unit provides power to operate the compressor and may be a gasoline or diesel engine. Compressors are governed by a pressure control system adjusted to compress air to a maximum pressure of 100 pounds per square inch. Compressor units are available in reciprocating, rotary, or screw design.

Reciprocating, rotary, and screw compressors are classified as either single-stage or multi-stage. In a single-stage compressor there is but one compressing element which compresses the air from the initial intake pressure to the final discharge pressure in one step. In the multi-stage machine there is more than one compressing element. The first stage compresses the air to an intermediate pressure, thence to one or more additional stages to be compressed to final discharge pressure. The multi-stage system is more efficient than the single-stage system because the air is cooled between stages, thus reducing a premature buildup of pressure due to temperature rise.

All military construction compressors are governed by a pressure control system. In a reciprocating compressor this control system causes the engine to idle and the suction valves to remain open when the pressure reaches a set maximum, thus making the compressor unit inoperative. When the air pressure drops below a set minimum, the pressure control system causes the engine to increase speed and the suction valves to close, thus resuming the compression cycle. The rotary compressor output is governed by varying the engine speed. The engine will operate at the speed required to compress enough air to supply the demand at a fairly constant pressure. When the engine has slowed to idling speed as a result of low demand, a valve throttles the amount of free air which may enter the compressor.

The screw compressor output is governed by automatic control which provides smooth, stepless capacity regulation from full load to no load in response to the demand for air. From a full load down to no load is accomplished by a floating-speed engine control in combination with the variable-inlet compressor.

COMPRESSED AIR SYSTEM

A compressed air system consists of one or more compressors, each with the necessary power source, control of regulation, intake air filter, after cooler, air receiver, and connecting piping, together with a distribution system to carry the air to points of use.

The object of installing a compressed air system is to provide sufficient air at the work area at pressures adequate for efficient operation of pneumatic tools being used.

Many construction jobs require more cubic feet of air per minute than any one compressor will produce. Terrain conditions often create problems of distance from compressor to operating tool. Since the air line hose issued with the compressor causes considerable line loss at distances further than 200 feet, a system has been devised for efficient transmission of compressed air over longer distances. This system is air manifolding (fig. 15-1). An air manifold is a large diameter pipe used to transport compressed air from one or more compressors over a distance without detrimental friction line loss. In construction work, air manifolds are usually constructed of 6-inch diameter pipe. A pipe of this size can carry 1200 cubic feet per minute of air (output from two 600 CFM air compressors) at 100 pounds per square inch with less than .035 pound pressure loss per 100 linear feet. One or more compressors pump air into the manifold and eventually "pressurize" it at 100 pounds per square inch; then air may be used at any point along the manifold by installing outlet valves and connecting air lines and pneumatic tools.

Compressors of different types should not be used on the same manifold. The difference in pressure control systems of a rotary, a reciprocating, and a screw compressor could cause one compressor to be overloaded while the other idled.

Any drop in pressure between the compressor and the point of use is an irretrievable loss. Therefore, the air distribution system is one of the most important elements of the compressed air system. In planning the air system, the following should be observed:

1. Pipe sizes should be large enough so that the pressure drop between the compressor and the point of use does not exceed 10 percent of the initial pressure.

2. Extremely long distribution lines should have air receivers located near the far ends or at points of occasional heavy use. Many peak demands for compressed air are instantaneous and of short duration, and storage capacity near such points prevents excessive drops.

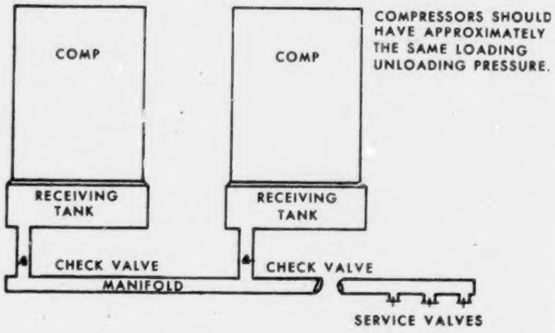


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Figure 15-1.—Methods of manifolding compressors.

3. Each header or main should be provided with outlets as close as possible to the point of use. This permits shorter hose lengths and avoids large pressure drops through the hose. Outlets should always be located at the top of the pipe line to prevent carryover of condensed moisture to the tool. Condensate drains should be located at appropriate places along the header or main line.

COMPRESSOR OPERATION AND MAINTENANCE

The following information is presented to give you an idea of how one of several types of compressors used by the SEABEES is operated and maintained.

The Worthington 600 CFM, portable, air compressor is a single cylinder, sliding vane, oil-cooled, positive displacement rotary compressor, connected through a friction disk clutch to a heavy duty industrial diesel engine (fig. 15-2). The complete assembly is equipped with a semi-eliptical spring mounting, pneumatic tires, and drawbar. The drawbar is normally located on the compressor end of the chassis. When the unit is coupled to a self-propelled crawler drill, supplying air for its tramming motors, this drawbar location keeps the radiator and oil cooler further away from the cloud of dust which the crawler rig can create.

The portable compressor comes completely equipped with all components essential for proper operation, including:

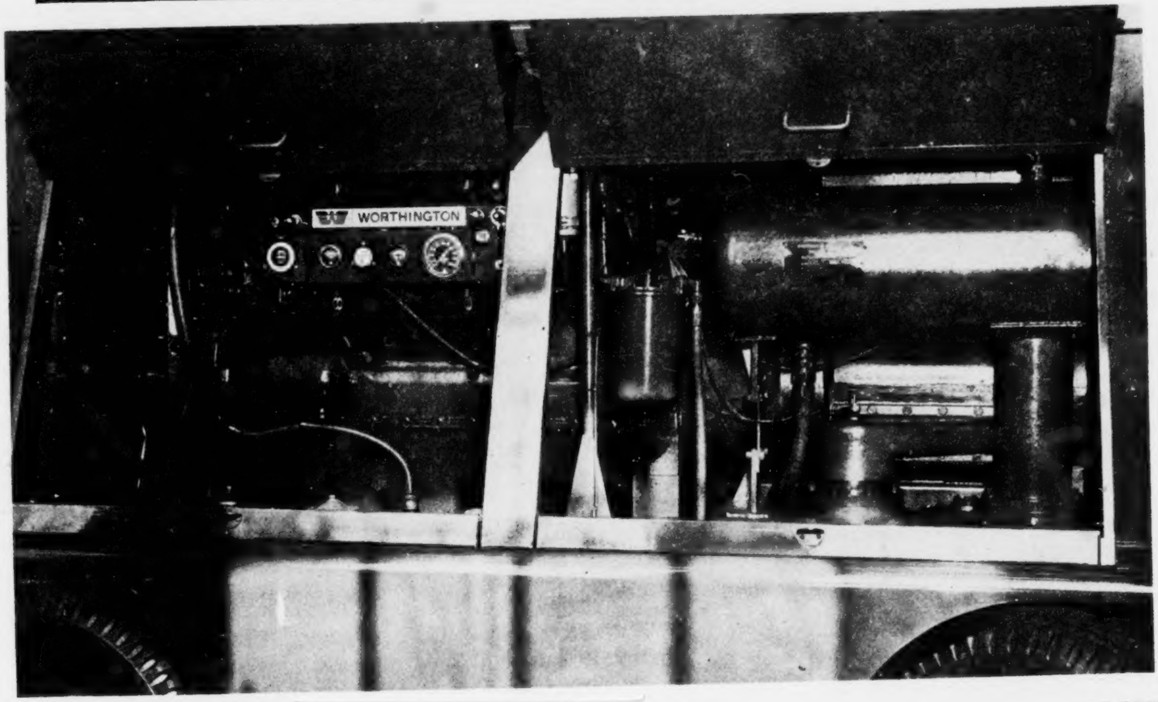

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Figure 15-2.—Worthington 600 CFM, portable, rotary air compressor.

1. A heavy duty, single, dry-type air cleaner to provide clean air for the compressor and engine with a minimum of service requirements.
2. Large cooler and radiator elements with ample capacity for efficient dependable cooling of the compressor oil and engine coolant.
3. Oil filters with replaceable cartridges for efficient filtration of the compressor oil and engine crankcase oil.
4. Automotive-type instrument panel with easy-to-read gages and electrical instruments.
5. Pneumatic regulating controls which provide for economical engine operation under all load conditions.
6. A combination thermostatic valve and bypass to assure rapid warm-up and optimum compressor performance over a wide range of surrounding air temperatures.
7. An electrically operated shut-down system to stop the engine in case of malfunction in the compressor and/or engine.
8. A blowdown valve to relieve, automatically, the pressure in the receiver and air flow system each time the engine is shut down.
9. An oil flow system which eliminates the need for an oil circulating pump.
10. A minimum pressure device to prevent the receiver discharge pressure from dropping below approximately 70 psi under all operating conditions.
11. Oil storage tanks, air receiver tank, and fuel tanks capable of containing enough fuel to operate the unit for a minimum of 8 hours.

COMPRESSOR LOCATION

Locate the compressor unit so that it is reasonably level. The design of this unit permits a 15-degree lengthwise and a 15-degree sidewise limit on out-of-level operation. The engine, not the compressor, is the limiting factor in any case. When the unit is to be operated out-of-level, it is important: (1) to keep the engine crankcase oil level near the high level mark (with the unit level), and (2) to have the compressor oil gage show nearly full (with the unit on the level).

Open the side curtains on both sides of the enclosure and leave them open whenever the unit is in operation. If the side curtains are closed and the engine running, the flow of air through the oil cooler and engine radiator will be impeded due to poor air circulation within the enclosure. The curtains may be left closed for a few minutes during cold weather starting to facilitate engine warm-up. However, when the compressor goes to work, open the side curtains. For specific operating instructions, check the instruction plate attached to the unit being used. The instruction plate will be similar to the one shown in figure 15-3.

ENGINE

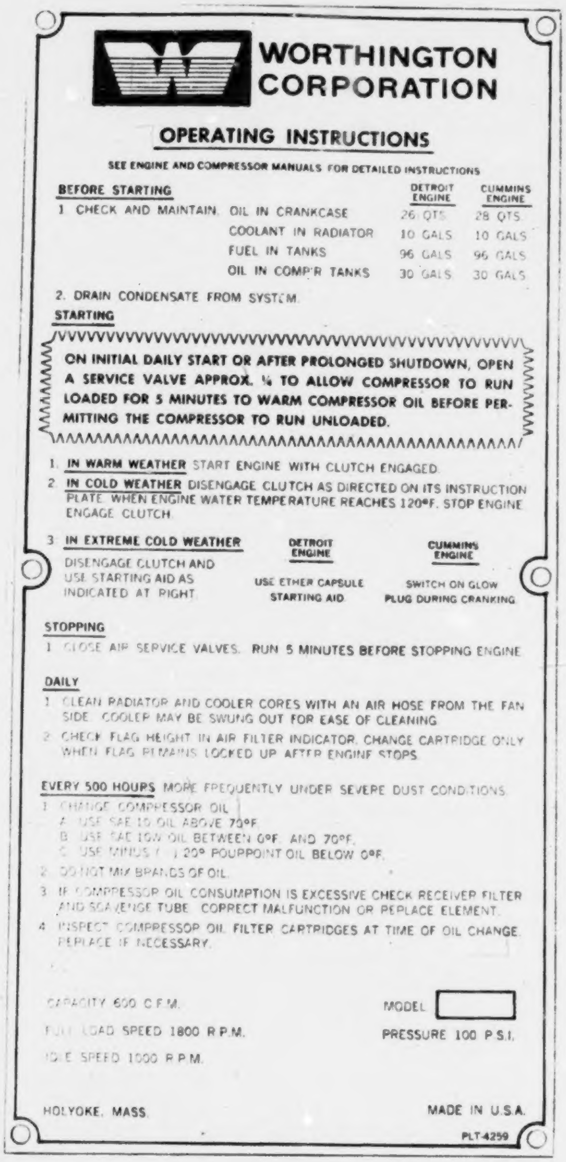
The heart of the compressor is the engine, which furnishes power for the compressor and produces air for the pneumatic tools used during drilling operations. It is necessary that you know how to properly start, operate, and maintain the compressor engine. For specific operating and maintenance instructions, check the engine operating manual furnished by the manufacturer of the particular engine used in the air compressor.

Air Cleaner

A two-stage, dry-type air cleaner, installed inside the engine enclosure at the right rear, filters the intake air (fig. 15-4). The clean air is supplied to the compressor suction as well as the engine air intake-manifold.

The first-stage element consists of a metal panel with about 40 round openings having fixed blades in each opening. The blades cause the inrushing air to spin and about 90 percent of all dust particles in the air drop to the dust bin below the panel. The dust bin should be removed by hand and emptied daily. Some models have a self-emptying dust bin that is piped into as aspirator in the exhaust pipeline, just beyond the muffler. When the aspirator is used, no alterations are allowed to be made to the engine muffler or exhaust pipe.

The second stage consists of a group of cylindrical, pleated paper tubes equal to the number of openings in the first-stage panel. The paper tubes are molded into a flexible plastic faceplate which seals the cartridge in place in the air cleaner housing without additional gaskets.



WORTHINGTON CORPORATION

OPERATING INSTRUCTIONS

SEE ENGINE AND COMPRESSOR MANUALS FOR DETAILED INSTRUCTIONS

BEFORE STARTING

		DETROIT ENGINE	CUMMINS ENGINE
1. CHECK AND MAINTAIN	OIL IN CRANKCASE	26 QTS.	28 QTS.
	COOLANT IN RADIATOR	10 GALS	10 GALS
	FUEL IN TANKS	96 GALS	96 GALS
	OIL IN COMP'R TANKS	30 GALS	30 GALS

2. DRAIN CONDENSATE FROM SYSTEM.

STARTING

ON INITIAL DAILY START OR AFTER PROLONGED SHUTDOWN, OPEN A SERVICE VALVE APPROX. ¼ TO ALLOW COMPRESSOR TO RUN LOADED FOR 5 MINUTES TO WARM COMPRESSOR OIL BEFORE PERMITTING THE COMPRESSOR TO RUN UNLOADED.

1. IN WARM WEATHER START ENGINE WITH CLUTCH ENGAGED.
2. IN COLD WEATHER DISENGAGE CLUTCH AS DIRECTED ON ITS INSTRUCTION PLATE. WHEN ENGINE WATER TEMPERATURE REACHES 120°F. STOP ENGINE ENGAGE CLUTCH.

3. IN EXTREME COLD WEATHER	DETROIT ENGINE	CUMMINS ENGINE
DISENGAGE CLUTCH AND USE STARTING AID AS INDICATED AT RIGHT	USE ETHER CAPSULE STARTING AID	SWITCH ON GLOW PLUG DURING CRANKING

STOPPING

1. CLOSE AIR SERVICE VALVES. RUN 5 MINUTES BEFORE STOPPING ENGINE

DAILY

1. CLEAN RADIATOR AND COOLER CORES WITH AN AIR HOSE FROM THE FAN SIDE. COOLER MAY BE SWUNG OUT FOR EASE OF CLEANING.
2. CHECK FLAG HEIGHT IN AIR FILTER INDICATOR. CHANGE CARTRIDGE ONLY WHEN FLAG REMAINS LOCKED UP AFTER ENGINE STOPS.

EVERY 500 HOURS MORE FREQUENTLY UNDER SEVERE DUST CONDITIONS.

1. CHANGE COMPRESSOR OIL
   A. USE SAE 10 OIL ABOVE 70°F.
   B. USE SAE 10W OIL BETWEEN 0°F. AND 70°F.
   C. USE MINUS ( ) 20° POURPOINT OIL BELOW 0°F.
2. DO NOT MIX BRANDS OF OIL.
3. IF COMPRESSOR OIL CONSUMPTION IS EXCESSIVE CHECK RECEIVER FILTER AND SCAVENGE TUBE. CORRECT MALFUNCTION OR REPLACE ELEMENT.
4. INSPECT COMPRESSOR OIL FILTER CARTRIDGES AT TIME OF OIL CHANGE. REPLACE IF NECESSARY.

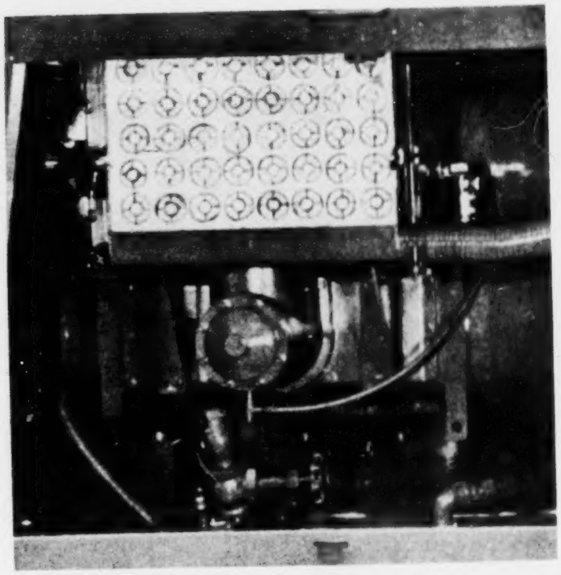
CAPACITY 600 C.F.M.
FULL LOAD SPEED 1800 R.P.M.
IDLE SPEED 1000 R.P.M.

MODEL ☐
PRESSURE 100 P.S.I.

HOLYOKE, MASS.
MADE IN U.S.A.
PLT-4259

115.378X
Figure 15-3.—Operating instruction plate.

On the side of the air cleaner housing, there is mounted a service indicator. As the second stage cartridge loads up with dirt, a red indicator flag gradually rises in the window. When the cartridge is completely loaded, the window



115.379X

Figure 15-4.—Air cleaner.

will show all red, and the flag will be locked in place. Then is the time to replace the second stage cartridge. Discard the old cartridge and reset the red flag so that the window shows clear. Cleaning used paper cartridges is not recommended.

Compressor

Drain cocks are provided at the bottom of the compressor suction control and the engine speed control. These cocks should be left open when the unit is standing idle, particularly in freezing weather. They must be closed before starting the engine.

Check the oil level in the oil storage tanks as indicated by the gage. If necessary, add oil in accordance with the oil specifications given in the manufacturer's lubrication manual.

Drain any condensate which may have accumulated in the bottom of the oil storage tanks. A drain cock is provided on the piping at the bottom of the left-hand oil storage tank. Open this cock and keep it open as long as water is draining out. Close the cock quickly when oil starts draining.

Operation of Clutch

The clutch friction disks are held in the engaged position by compression springs. A clutch shifter using a system of hydraulically operated pistons forces the disks apart against the spring compression to disengage the clutch. The clutch should remain in the engaged position at all times except during engine warm-up or tune-up periods. This prevents undue strain on the compression springs and shifter mechanism, and minimizes possible loss of hydraulic fluid due to exerted pressures.

At the base of the hand-operated hydraulic pump is a small brass valve with built-in safety interlock. This lock prevents engagement and/or disengagement of the clutch while the engine is running.

When the engine stops, the clutch sleeve can be pushed down easily, to expose a knurled knob which is used to engage and disengage the engine clutch. No attempt should ever be made to move the clutch sleeve and turn the knob when the engine is running. Always shut down the engine before engaging or disengaging the clutch.

To disengage the clutch, close the hydraulic pump line by finger tightening the knurled knob. Turn the knob clockwise as far as it will go. Pump the required pressure into the clutch shifter cylinders with several strokes of the pump handle. A built-in pressure relief valve prevents over-pressurizing.

To engage the clutch, turn the knurled knob counterclockwise three or four turns until the pump handle offers little resistance to pumping. Leave the knob in this position.

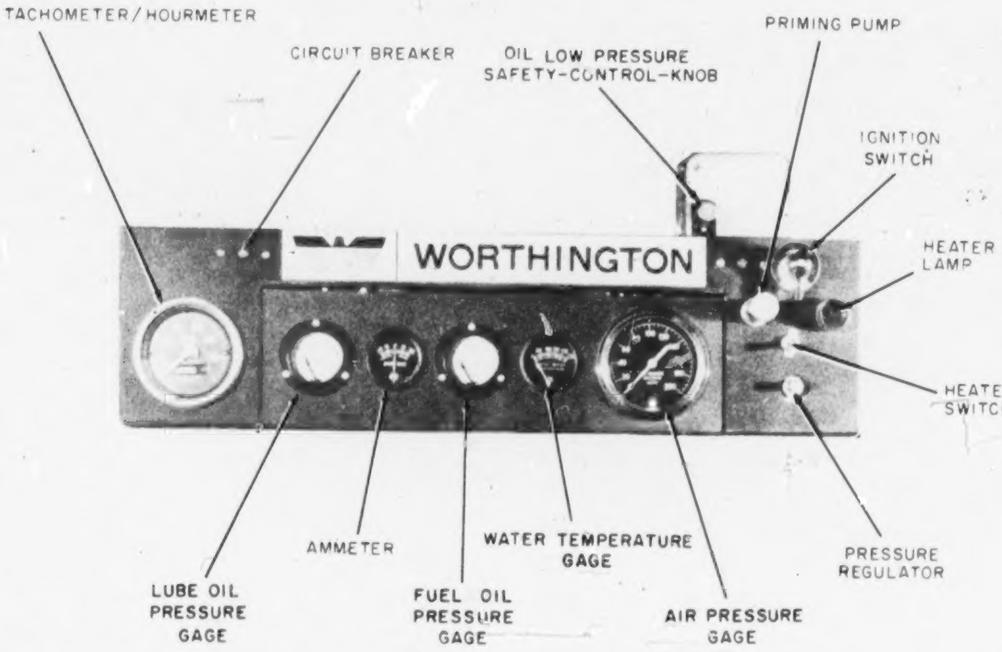
Starting Unit

The following steps should be taken when starting the engine during mild or warm weather:

1. Open service valves about one quarter—not wide open.

NOTE: The reason for starting with the service valves partly open is that they aid in quicker warm-up of the compressor oil.

2. Make sure the clutch is in engaged position.



115.383X

Figure 15-5.—Instrument panel.

3. Position the low-pressure, engine-oil-system safety-control-knob to ON (fig. 13-5).

4. Turn the ignition switch to start position. Immediately after the engine starts, release the ignition switch. If the engine fails to fire within 30 seconds, release the ignition switch and allow the starting motor to cool off for a few moments before trying the starter again.

5. With the engine running, check the engine oil pressure gage. If no pressure is indicated, turn the engine off. When the oil pressure indicates above 22 psi, continue to operate the engine and check the low-pressure engine-oil switch. The knob on this switch should be in the RUN position.

NOTE: The engine oil pressure gage indicates erratically until the engine oil warms up.

6. After the engine has run about 3 minutes, check the engine coolant temperature gage. The gage should indicate less than 210°F. If the gage is showing more than 210°F, SHUT OFF THE ENGINE.

7. After 5 minutes of operation, close the service valve and attach the hose or service line of the tool or device to be operated.

8. Open the service valves fully and start the work. After start-up, the unit automatically provides compressed air at the discharge service valves. Only periodic checking of the gages on the instrument panel is then required.

9. When starting the engine during the day, after the first daily start-up, the above warm-up steps may be eliminated.

Stopping Unit

When stopping the unit at the end of the day's run, the following steps should be observed:

1. Close the service valves and permit the engine to run at idle for 5 minutes. This will allow the engine coolant temperature to level off and the entire unit to cool down.

2. Turn the ignition switch to the OFF position.

Cold Weather Starting

The following steps should be completed during cold weather starting:

1. Disengage the clutch. This will permit engine warm-up at idling speed.
2. Start the engine using the heater switch and priming pump in accordance with the engine manual.
3. Warm the engine until the engine coolant temperature reaches 120°.
4. Turn the ignition switch to OFF.
5. When the engine has stopped, engage the clutch and start the engine again with the service valves partly open.
6. When the compressor has run for several minutes and the gages indicate normal operating conditions, connect up the tools and go to work.

Multiple Unit Operation

When the compressor unit is connected in multiple with other compressors into a common header or receiver, a check valve must be installed between the compressor unit and the common header. This permits the release of air receiver pressure immediately after shutdown without affecting the operation of the other compressors. Use of this check valve will also prevent contamination of the compressor system with scale, water, and oil which could be blown back from the header or receiver. Use a 2-inch check valve with a maximum pressure drop rating of 2 psi at 100 psi, when required, and with a 600 CFM capacity rating.

LUBRICATION

The lubrication chart in the operator's manual for the particular make and model of compressor you are operating will show you where the unit should be lubricated, how often to lubricate, and what lubricant to use. The frequency will vary depending upon operating conditions. Operating under abnormal conditions requires more frequent service.

CAUTION: Before servicing the compressor air system or compressor oil system, open the service valves to the atmosphere to relieve all pressure in the systems.

AIR COMPRESSOR SAFETY

General safety precautions for air compressors are as follows:

Be sure the air at intake is cool and free from flammable gases or vapors.

Do not permit wood or other flammable materials to remain in contact with the air discharge pipe.

Immediately secure a compressor if the temperature of the air discharged from any stage rises unduly or exceeds 400°F.

Pressure gages must never be made inoperative except when they are to be removed for some valid reason.

Never kink a hose to stop the air flow. Keep the clamps on the hose tight.

When starting an air compressor, check the safety valves, pressure valves, and regulators to determine that they are working properly.

Do not leave the compressor after starting it unless you have made certain that the control, unloading, and governing devices are working properly.

Do not run an air compressor faster than the speed recommended by the manufacturer.

Use only the proper grade of oil recommended by the manufacturer, and avoid the application of too much oil. Use only oils which have high flashpoints to lubricate the air cylinders of air compressors.

Keep compressors, tanks, and accompanying piping clean to guard against oil vapor explosion. Clean intake air filters periodically.

Use only soapy water or suitable nontoxic, nonflammable solution for cleaning compressor intake filters, cylinders, or air passages. Never use benzene, kerosene, or other light oils to clean these parts. These oils vaporize easily and will form a highly explosive mixture under compression.

Turn off the motor before making adjustments and repairs on an air compressor.

Before working on or removing any part of a compressor make certain that the compressor is secured and cannot be started automatically or by accident, that air pressure in the compressor is completely relieved, and that all valves between the compressor and receivers are closed.

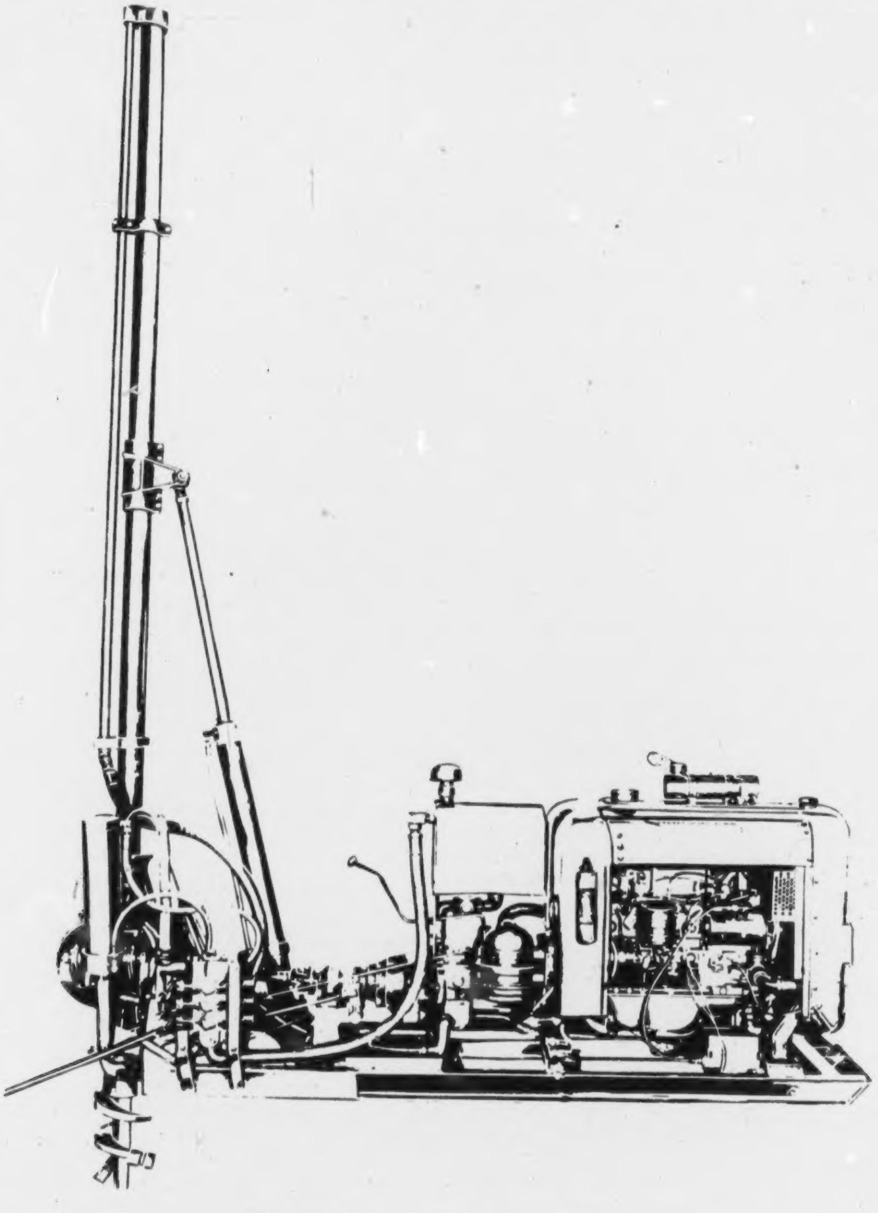
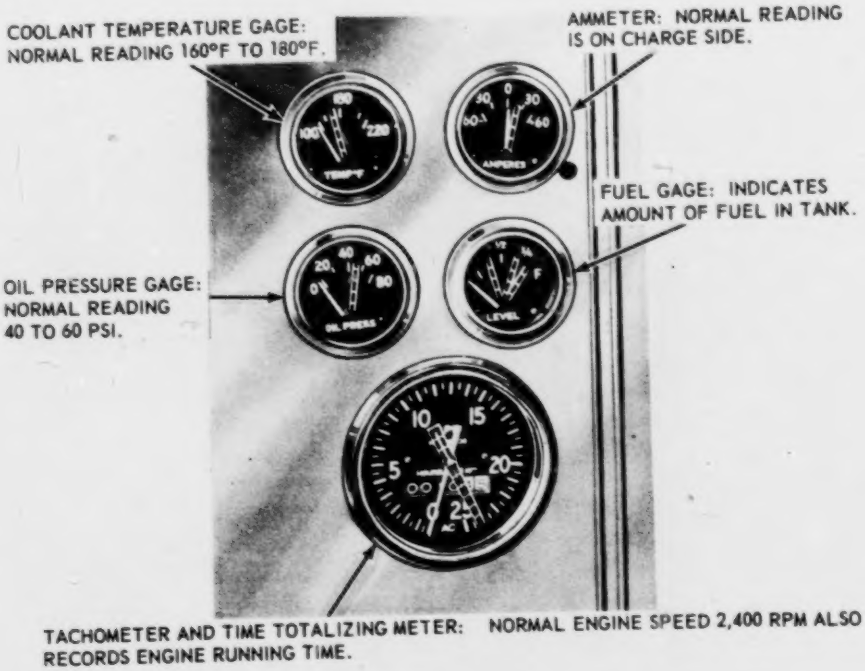


Figure 15-6. — Power earth auger.

115.484

POWER EARTH AUGER

The earth auger is used to dig holes for placing posts, poles, and explosives charges. It is also used to remove soils for testing. Among other things, the earth auger is very useful in subsurface soil explorations for boring holes up to 20 inches in diameter and up to 9 feet in depth. The power earth auger (fig. 15-6) is a self-contained, hydraulically operated and positioned


COOLANT TEMPERATURE GAGE: NORMAL READING 160°F TO 180°F.
AMMETER: NORMAL READING IS ON CHARGE SIDE.
FUEL GAGE: INDICATES AMOUNT OF FUEL IN TANK.
OIL PRESSURE GAGE: NORMAL READING 40 TO 60 PSI.
TACHOMETER AND TIME TOTALIZING METER: NORMAL ENGINE SPEED 2,400 RPM ALSO RECORDS ENGINE RUNNING TIME.

115.485

Figure 15-7.—Instruments, power earth auger.

earth boring machine. The boring assembly can be operated from vertically downward to 45 degrees from vertical. The power earth auger is normally mounted on the bed of a truck to increase down pressure and aid in transporting.

The auger, at full speed in fourth gear, will rotate at less than 150 rpm, or in low gear at not more than 40 rpm. The auger hydraulic valve levers are placed so that you can observe the boring operations and the engine instruments at the same time.

The earth auger is usually driven by a gasoline engine. The auger assembly consists of the auger, kelly bar, final drive assembly, and right-angle drive assembly. Operation of the boring assembly is controlled by the auger clutch. The auger clutch is a multiple-disk, dry-friction plate, used to engage and disengage the kelly bar.

OPERATION OF POWER EARTH AUGERS

To give you some idea as to the operation of a power earth auger, the information given is on the Texoma Enterprises Earth Auger, Jaques model TJ 254, and applies ONLY to that machine. Figures 15-7 and 15-8 show the instruments and controls of this earth auger.

Starting the Power Earth Auger Engine

There are certain steps you must take in starting the auger. After performing the routine prestart checks of the engine crankcase oil level, transmission oil level, fuel supply, battery water level, coolant level, and hydraulic oil level, be sure that the proper amount of lubricant, water, and electrolyte is added, as required, to bring the specific unit to the proper level or full mark. Place all controls in the neutral position and then open the fuel shutoff valve and the hydraulic oil shutoff valve. By following the step-by-step procedures shown in figure 15-9, you should have no difficulty starting the auger engine.

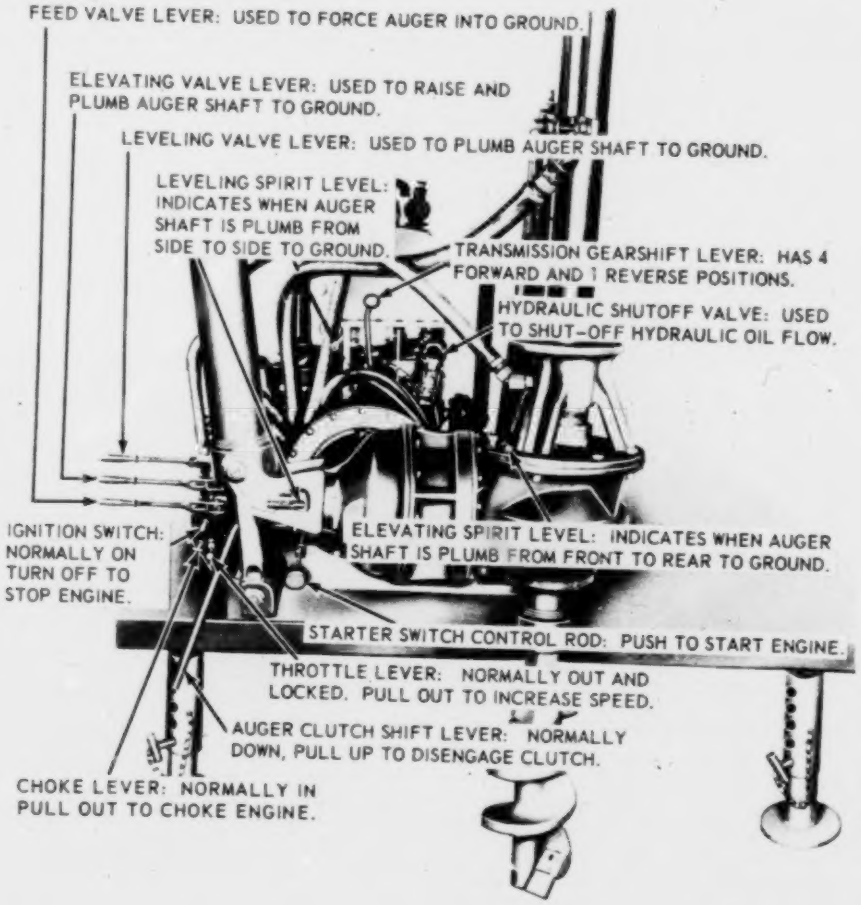

FEED VALVE LEVER: USED TO FORCE AUGER INTO GROUND.
ELEVATING VALVE LEVER: USED TO RAISE AND PLUMB AUGER SHAFT TO GROUND.
LEVELING VALVE LEVER: USED TO PLUMB AUGER SHAFT TO GROUND.
LEVELING SPIRIT LEVEL: INDICATES WHEN AUGER SHAFT IS PLUMB FROM SIDE TO SIDE TO GROUND.
TRANSMISSION GEARSHIFT LEVER: HAS 4 FORWARD AND 1 REVERSE POSITIONS.
HYDRAULIC SHUTOFF VALVE: USED TO SHUT-OFF HYDRAULIC OIL FLOW.
IGNITION SWITCH: NORMALLY ON TURN OFF TO STOP ENGINE.
ELEVATING SPIRIT LEVEL: INDICATES WHEN AUGER SHAFT IS PLUMB FROM FRONT TO REAR TO GROUND.
STARTER SWITCH CONTROL ROD: PUSH TO START ENGINE.
THROTTLE LEVER: NORMALLY OUT AND LOCKED. PULL OUT TO INCREASE SPEED.
AUGER CLUTCH SHIFT LEVER: NORMALLY DOWN, PULL UP TO DISENGAGE CLUTCH.
CHOKE LEVER: NORMALLY IN PULL OUT TO CHOKE ENGINE.

Figure 15-8.—Controls, power earth auger. 115.486

Steps for Auger Operation

Follow the procedures below to place the power earth auger in motion after the engine has been started:

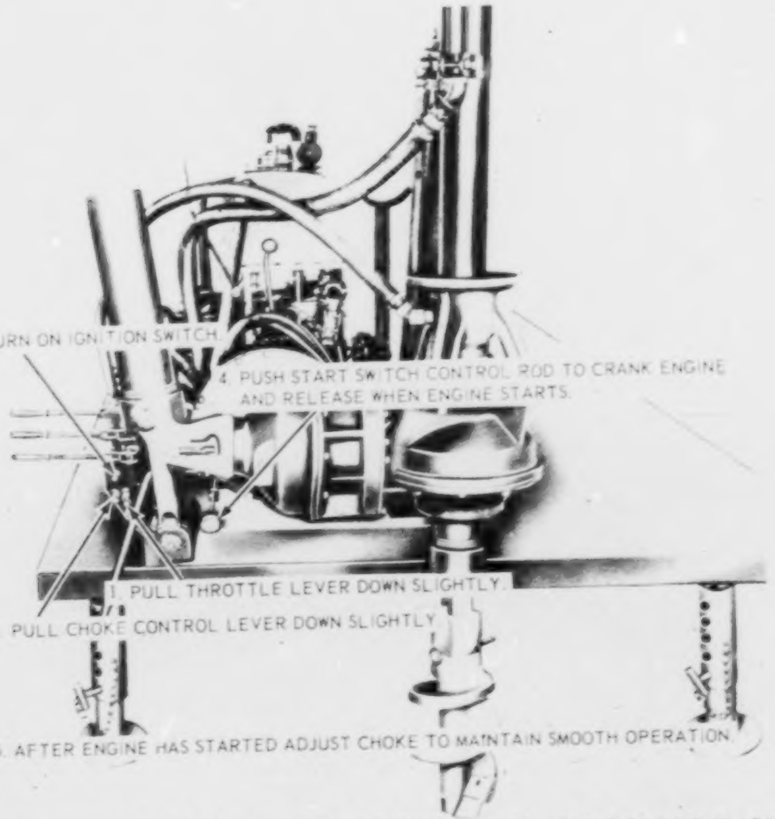
1. Disengage the engine clutch and shift the transmission into fourth gear.
2. Engage the engine clutch and run the engine at idle speed.
3. Pull the elevating valve lever to elevate the auger shaft into the vertical position and plumb as indicated by the elevating spirit level.
4. Engage the auger clutch by pressing down on the auger clutch shift lever and allow the auger shaft to rotate for 5 minutes.

NOTE: Do not run the engine faster than idle until the auger gears are thoroughly warmed up.

5. After the auger has been warmed up, disengage the auger clutch.

Stopping the Earth Auger Engine

To stop the auger engine, observe the steps as given in figure 15-10 after disengaging the engine clutch and shifting the transmission into neutral.



3. TURN ON IGNITION SWITCH.

4. PUSH START SWITCH CONTROL ROD TO CRANK ENGINE AND RELEASE WHEN ENGINE STARTS.

1. PULL THROTTLE LEVER DOWN SLIGHTLY.

2. PULL CHOKE CONTROL LEVER DOWN SLIGHTLY.

5. AFTER ENGINE HAS STARTED ADJUST CHOKE TO MAINTAIN SMOOTH OPERATION.

CAUTION: DO NOT CRANK ENGINE FOR MORE THEN 30 SECONDS WITHOUT PAUSING AT LEAST ONE MINUTE TO ALLOW THE STARTER TO COOL.

115.487

Figure 15-9.—Starting the earth auger engine.

TECHNIQUES OF AUGER OPERATION

Auger operational techniques applied under ordinary circumstances are described below. Figure 15-11 shows the auger controls and how the auger is positioned using these controls.

Raising and Lowering Auger

By using the ELEVATING VALVE LEVER, the auger shaft can be raised or lowered for transporting as shown in view B of figure 15-11.

Leveling Auger

By using the LEVELING VALVE LEVER, the auger shaft can be tilted to the right or left as shown in view A of figure 15-11. The LEVELING SPIRIT LEVEL should be used to plumb the auger shaft.

Drilling and Retracting Auger

After the auger shaft has been placed in the desired drilling position you are ready to begin drilling operations. This is done by engaging the auger CLUTCH LEVER, pulling back on the THROTTLE LEVER to increase engine speed, and then pushing forward on the FEED VALVE LEVER to lower the auger into the ground as shown in view C, figure 15-11.

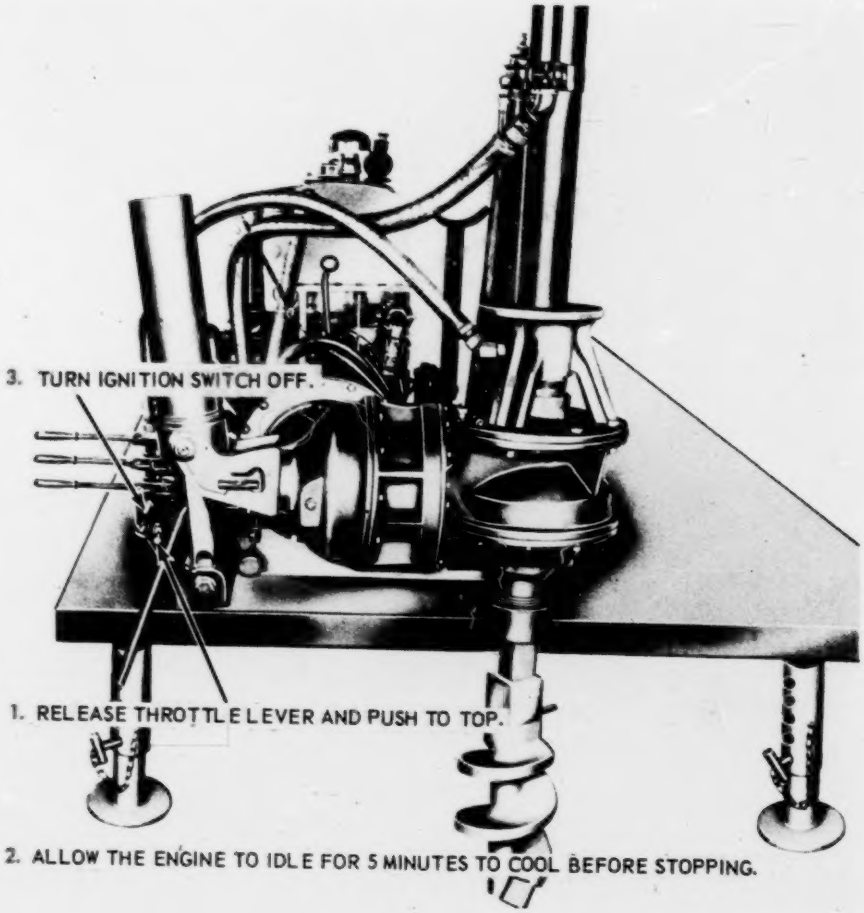

3. TURN IGNITION SWITCH OFF.
1. RELEASE THROTTLE LEVER AND PUSH TO TOP.
2. ALLOW THE ENGINE TO IDLE FOR 5 MINUTES TO COOL BEFORE STOPPING.

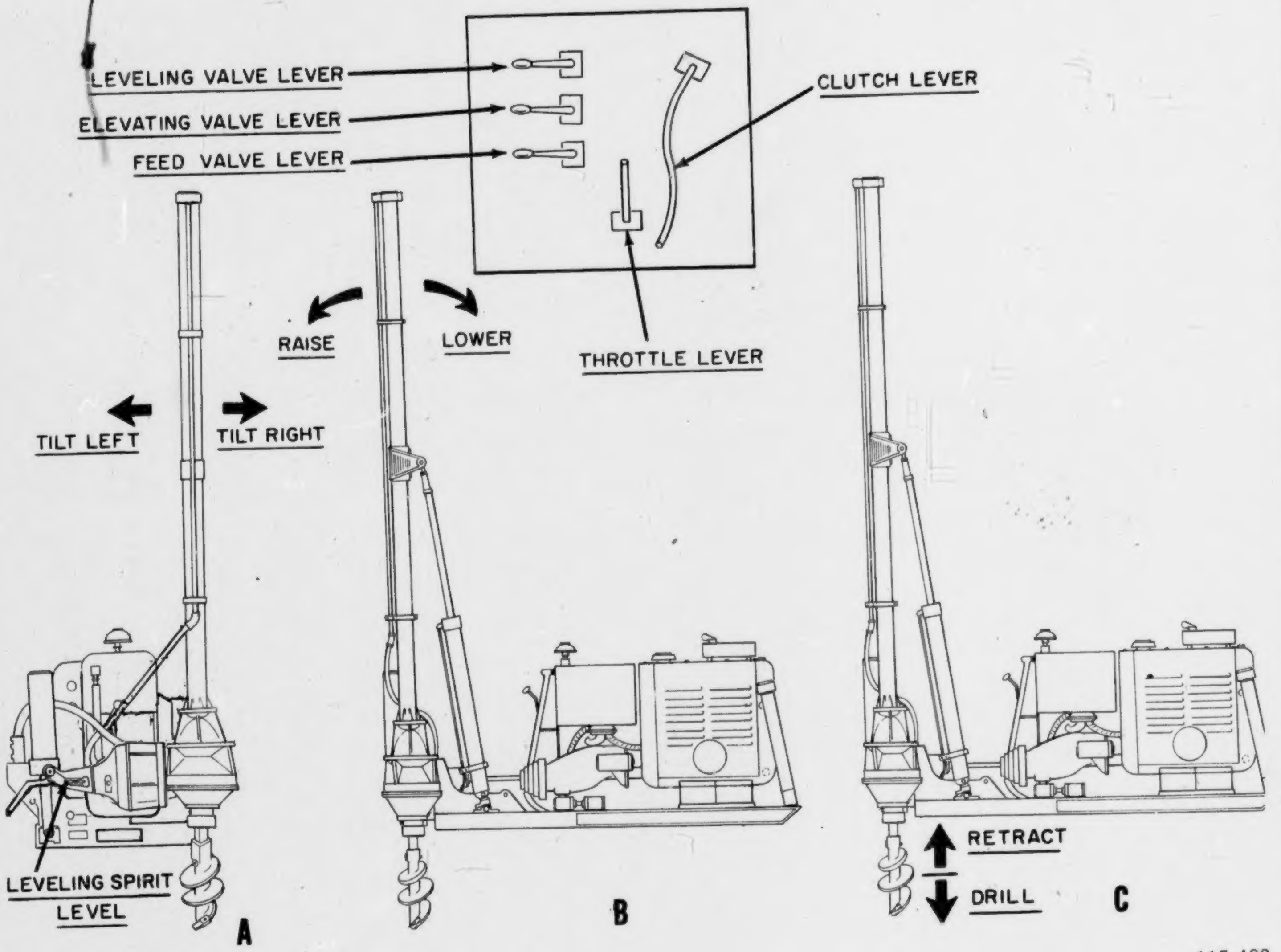
Figure 15-10.—Stopping the earth auger engine. 115.488

CAUTION: Do not overspeed the auger. Run the engine at slow speed until the texture of the material can be determined.

When the auger is deep enough in the ground to be loaded with dirt, disengage the auger CLUTCH LEVER and pull back on the FEED VALVE LEVER to raise the auger from the hole. After the auger has cleared the hole, engage the auger CLUTCH LEVER (fig. 15-11) to rotate the auger and to clear the unit of dirt. Remember, as you raise the auger, push the hand THROTTLE forward to lower engine speed. Repeat the directions given above until the hole being drilled is at the desired depth.

SECURING

When securing a truck-mounted power earth auger, position the auger for traveling and secure the auger engine. Be sure to close the fuel shutoff valve and the hydraulic oil shutoff valve. Drive the truck to the designated securing area, and position the earth auger in a safe manner. After the truck has stopped, disengage the engine clutch, position the main transmission shift lever to neutral, engage the truck parking brake, and turn the key switch counterclockwise to the OFF



115.489

Figure 15-11.—Using auger controls for positiong of auger.

position. Secure all doors and windows before leaving the truck.

AUGER CARE AND MAINTENANCE

The manufacturer's maintenance manuals contain complete instructions on the care and maintenance, including lubrication requirements, for the auger. Whatever the type of auger you are operating, ensure the following requirements are met:

1. Check the auger daily when in use for loose nuts and bolts and for worn parts.
2. Check the fuel, lube oil, battery, coolant levels, and hydraulic oil.
3. Fill the fuel tank at the end of each workday.
4. Keep the auger free of dirt and mud.
5. When you leave the auger for an extended period, disengage the auger clutch lever, as well as the engine clutch lever, and place the engine transmission in neutral.

Proper lubrication of an auger is of prime importance in prolonging its life. Fuels, oils, and greases should be of a good quality and kept free of dirt, water, and other foreign matter. It is imperative that all level plugs or pressure grease fittings be cleaned prior to opening for level check or prior to pressure gun installation.

AUGER SAFETY

General safety precautions for power earth augers are as follows:

1. Don't leave the auger unattended when drilling.
2. Don't engage the engine or auger clutch lever too fast. Engage these levers gradually to prevent damage to the gear cases and other moving parts.
3. Don't fill the fuel tank with the engine running.
4. NEVER attempt to remove an object from the auger while the auger is running.
5. Don't let anyone stand close to the rotating auger.
6. Align the auger with the hole being drilled.
7. Do not feed the auger too quickly during drilling.
8. Be sure the rig is on firm ground. Use support jacks when operating the auger in hardpan or rocky soil, which will cause the auger to bounce.
9. Use supporting jacks when operating the auger in thick clay or mud-like material, which will cause suction when removing the auger from the holes.
10. Wear protective headgear (safety hat) and safety shoes when operating the auger.
11. Be sure to secure all machinery while repairs, adjustments, or manual lubrications are being made.
12. Open holes, in which poles or other construction material have not been placed, must be provided with suitable covering over which men or equipment can safely pass.

PORTABLE ROTARY ROCK DRILL

The rotary rock drill (fig. 15-12) is an air-operated percussion tool used for drilling holes in rock. It is also used for various purposes in construction work, such as breaking pavement or other concrete structures.

Rock drills form only a part of a much larger family of air-operated percussion tools including chipping and riveting hammers, clay spades, backfill tampers, and many others.

The rock drill shown in figure 15-12 is of the free piston hammer type. It is operated by compressed air.

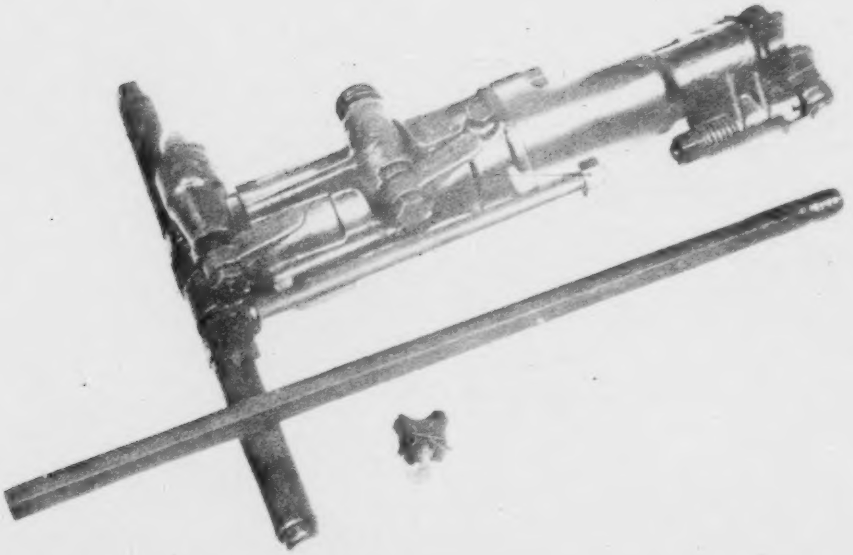
The information given applies to the HAND-HELD ROTARY ROCK DRILL which is used primarily for drilling holes on which the drills are hand-held by the operator. Four classes of rotary rock drills are available.

The first class includes very light drills weighing approximately 15 lbs. These drills are used for drilling shallow holes in quarry work.

The second class includes light drills weighing 25 to 40 lbs. These drills are used for light work, such as potholing, drilling concrete, and so forth.

The third class includes drills weighing from 40 to 50 lbs. When you are drilling in limestone and other soft rock, a drill of this class is used.

The fourth class includes drills weighing from 50 to 65 lbs. Hand-held drills in this class are used for drilling holes up to 6 feet in depth during quarry operations.



115.490

Figure 15-12.—Rotary rock drill.

All of the foregoing drills use hollow drill steel and are built with automatic rotation.

Hand-held rotary rock drills used in quarry work may be of the dry drill type, the blower type, or the wet drill type.

The DRY DRILL allows very little air to pass through the drill steel while drilling. When the hammer is not running, the dry drill allows sufficient air to pass through for cuttings to be blown out of the hole.

The BLOWER TYPE DRILL is built so that a steady supply of air passes through the drill steel to assist in removing cuttings from the hole while the hammer is running. This type also permits air to pass through the drill steel when the hammer is not running.

The WET DRILL gives a constant supply of water through the drill steel while the hammer is running.

CARE AND HANDLING OF ROCK DRILLS

The rotary rock drill is a precision tool designed to do rough work and to stand up under hard service. Although it does not require coddling, it does deserve good treatment. Good treatment begins with correct operation, which in itself is a preventive maintenance measure because it prolongs the useful life of the machine and minimizes the need for repairs. With proper handling and upkeep, your rock drill will turn out thousands of hours of hard service with little trouble.

Before operating the drill, make sure the drill steel and bits are in good condition. Drill steel center holes should be clear and shanks should be flat and square, not chipped or rounded off. Rock bits should be sharp—dull bits are hard on the drill and the operator.

Many of the troubles which arise from faulty operation can be eliminated or minimized if the following precautions are observed in the care and handling of rock drills:

NEVER pound on stuck steel. Nothing is accomplished thereby and you may damage the drill and bit.

NEVER retract the steel at full throttle. This may damage the front head parts.

NEVER strike the drill with tools. You may dent the cylinder or cause other damage.

NEVER try to turn a drill in the hole when the steel is stuck. Pawls will break if the drill is turned in the opposite direction from normal rotation.

NEVER try to repair the drill on the job. Take it to the maintenance shop.

NEVER drag a drill along the ground, as the exhaust ports and other openings will scoop up dirt which will cause malfunctioning and possible failure.

ALWAYS blow out the air supply hose and flush out the water hose before connecting to the drill. This rids the line of dirt.

ALWAYS be sure the drill is well lubricated. Adjust the line oiler (discussed later) so that the steel shank always shows an oil film. This is necessary to prevent fogging.

ALWAYS keep side rods tight and at equal tension.

ALWAYS keep drill aligned with drill steel and hole. Hold drill firmly and apply even pressure with both hands.

ALWAYS protect your drill when blasting occurs.

LUBRICATION

Proper lubrication is an important factor in realizing the longest useful life from a rock drill; it might be said that most rock drill failures and complaints arise from faulty lubrication. As an operator, you should realize that good lubrication practices conscientiously carried out will make your drill more productive and easier to operate, with fewer delays and breakdowns.

Correct lubrication of rock drills is dependent on two main factors:

1. Selection of the proper lubricant.
2. Application of lubricant in sufficient amount to assure adequate lubrication of all working parts.

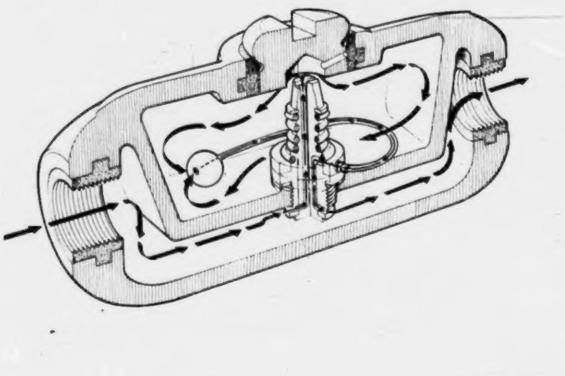
Selection of lubricant for rock drills involves the choice of a quality product, which will provide adequate protection for the drill under all operating conditions. The lubricant must have the correct viscosity to assume uniform rate of feed for the operating temperatures. Viscosity recommendations covering a wide temperature range are usually indicated by SAE numbers in the operation and maintenance manual furnished with the drill. Oil viscosity may vary from SAE 10 (for low temperature operation) to SAE 50 (for high temperature) depending on the type of drill.

The following describes the characteristics of a good rock drill oil.

1. It must have high film strength—ability to withstand shock loads.
2. It must not "blow" readily, nor interfere with valve action.
3. It must not fog, nor exhaust toxic gases.
4. It must be non-corrosive under all operating conditions.
5. It must wet out all parts rapidly.
6. It must lubricate perfectly at maximum drill speed, at both high and low temperatures.
7. It must not form gummy residues with either hot or cold air.
8. It must always be uniform.

The importance of using an air line oiler (fig. 15-13) with each rock drill and servicing it at regular intervals cannot be overemphasized. Obviously, the air line oiler should never be allowed to run dry. Through experience, you will be able to determine the time interval that the drill can safely be run before servicing is needed. Lubrication intervals will vary according to the type of drill, type of service (wet or dry drilling, continuous or intermittent operation), and local conditions. There must be a continuous presence of oil on all working surfaces and the easiest way to assure this is to make certain that the shank of the drill steel is wet with a light film of oil at all times during operation and the air line oiler should be adjusted to maintain this condition. Presence of oil at the exhaust ports is another indication that oil is passing through the drill and can be checked by placing a piece of white paper near the exhaust. Oil droplets should appear on the paper. Excessive lubrication, caused by incorrect adjustment of the line oiler, will produce fogging which is disagreeable and wasteful.

Drill manufacturers recommend installing the air line oiler in the airhose not more than



115.491
Figure 15-13.—Cutaway view of air line oiler.

10 to 12 feet from the drill. If the air line oiler is located too great a distance from the drill, oil droplets will tend to accumulate on the inside of the hose and the oil will be delivered to the drill intermittently.

ROCK DRILL SAFETY

Avoid injury to yourself and fellow workers by operating your drill safely. Follow these rules:

1. Keep hands off trigger or throttle until ready to start drilling.
2. Maintain your balance at all times.
3. Never get your face close to the drill.
4. Wear safety shoes, safety glasses, and gloves.
5. Never rest an air tool on your toes.
6. Never point a drill at another person or start an air drill while it is laying on the ground.
7. Don't use your body to control an active drill.
8. Don't engage in horseplay.
9. Never point an airhose at yourself or other personnel.
10. Always keep both hands on handle of drill while operating.
11. Always bleed the air line before removing from drill.

CRAWLER-MOUNTED ROCK DRILL

A component of the quarry set which includes all items of equipment needed to drill is the crawler-mounted rock drill. This drill is a self-propelled unit, designed primarily to drill vertical and angular blast holes in rock. The track mounting gives this drill good on-the-job mobility as well as excellent drilling stability when situated in rough terrain. There are several makes and models of crawler-mounted rock drills used by the SEABEES.

The crawler drill is composed of two basic assemblies—the carrier unit and the drill unit.

The carrier consists of two crawler tracks, each powered by a separate air motor. The tracks may be either all steel or rubber padded, 10 to 12 inches wide. They are driven by the air motors through a gear train that includes forward, reverse, and neutral. Each track has its own brake. The crawler drill is turned by locking or reversing one track while moving the other forward. The crawler drill can tow a 600-cfm air compressor to the jobsite. The compressor feeds the drill through a 2-inch airhose. The operator's controls are grouped at the rear of the crawler drill. These controls allow him to "drive" the crawler unit or manipulate the drill itself.

Some crawler drill models have a seat or a standing platform for the operator's use during travel; other types require him to walk behind the unit as it moves.

The drill unit is connected to the carrier by a hydraulic boom assembly. Movements of the boom are controlled by two hydraulic units; one for lift, another for swing. These units allow a variety of drilling positions regardless of the crawler's mounting alignment. The drill frame is made of two 6-inch steel channels between which runs a 1-inch chain. The chain moves the drill up or down the channel assembly, just as on a wagon drill. The drill is of the piston type which rotates the steel slightly after each blow. Crawler drills have forward, neutral, and reverse rotational ability since the drill steels have threaded couplings on each end. These threaded steels allow simple addition—rather than replacement—of new steels as the drill hole deepens.

With a sufficient air supply, the crawler drill can drill up to 100-foot boreholes in all kinds of rock. It can propel itself at 2-1/2 miles per hour or pull a 600-cfm compressor at 2 miles per hour. Drill steels, with various type threads, are available in lengths ranging from 6 to 14 feet and in diameters from 1 1/4-inch to 1 1/2-inch. The drill steels may be round or hexagonal in cross section. Drill bits are of the "X" and cross type with tungsten carbide inserts and buttonhead bits. The bit sizes range up to 4-1/2 inches.

PRINCIPLES OF OPERATION

When operating the crawler-mounted rock drill, follow the instructions prescribed in the manufacturer's operating manual. If the manual is not available, the general instructions which follow may be used as a guide:

Figures 15-14 through 15-16 show the positions, parts, and controls for this type rock drill.

To position the rock drill, open the air-inlet valve, tram to drilling position; and pump the tramming handbrake to hydraulically lock both tracks. Then, open the hydraulic pump motor control lever; this allows the bank of the hydraulic cylinder controls (which are properly identified as to their function) to be activated. By operating the proper control levers, you can now position the rock drill — without time-consuming adjustments — in a variety of positions as shown in figure 15-15.

After positioning the mast in the desired position for drilling, be sure the boom mast foot support (fig. 15-16) is driven into the ground by the power cone cylinder which is activated by the application of the appropriate hydraulic cylinder control lever (fig. 15-14) to firmly set the mast before starting to drill. Once positioned, you can now move the hydraulic pump motor control lever to the off position (fig. 15-14). Open the necessary air control valves located on the mast (fig. 15-14). Assuming the drill steel is in position and the centralizer (fig. 15-16) is closed, drilling may now commence. Open the 3/4-inch air-blow valve control (fig. 15-14); this action starts the air through the drill steel and bit (fig. 15-16) and keeps the rock dust out of the way and the drill hole clean.

Using approximately 1/2 throttle on the remote air rotation control valve (fig. 15-14) to start the drifter, start the feed motor control (fig. 15-14) and bring the drifter down to start the hole. Open the throttle for continued drilling, putting the drill in the forward rotation and moving counterclockwise; the centralizer (fig. 15-16) must be open.

NOTE: Watch the drill steel rotation for stuttering, which can happen if you feed the drill steel too fast. Bouncing or pinging noise of the drill indicates you are not feeding the drill steel fast enough.

After drilling the complete length of the drill steel and an additional drill steel is to be added or removed, the general instructions which follow may be used as a guide.

Keep in mind that the forward rotation of the rock drill is counterclockwise and that the drifter must be shutoff to change the direction of rotation. When adding drill steel, pick the drifter up partially from the drilled position. Then place the rotation control valve in neutral (fig. 15-14), leave the air blow valve partially on (fig. 15-14), and disconnect the striker bar (fig. 15-16). Now put the rotation control valve in reverse (fig. 15-14) and, by applying pressure on the coupling with a wrench or using your foot, start the drifter slowly; allow the striker bar to come completely loose from the coupling. Turn the drifter rotation control valve to the forward position and run the drifter back up the mast. Take the next section of drill steel and thread it into the coupling manually. Feed the drifter down slowly with partial throttle to allow the coupling to mate with the drill steel. Then continue with drilling operations.

To remove drill steel from the drill hole, run the drifter to the top of the mast and expose the coupling. To prevent the drill steel from dropping back into the finished drill hole, make certain that you close the centralizer located under the coupling (fig. 15-16).

When the last length of drill steel is pulled from the hole (air flow must be continuous to blow rock chips from the hole), the last drill steel may be left on the drill with the bit to start the next hole.

To lift the mast from the ground, turn on the hydraulic pump motor; then, release the hand valve of the hydraulic track lock pump and tram to the next drill hole.

Some additional hints which should aid the operator follow:

1. If the air blow stops, discontinue all drilling or removing of the drill from the hole. Check and see if the air blow valve is open fully; if so, continue to rotate and pull drill steel.

2. When pulling drill steel, allow the air blow to keep blowing out the rock chips; you

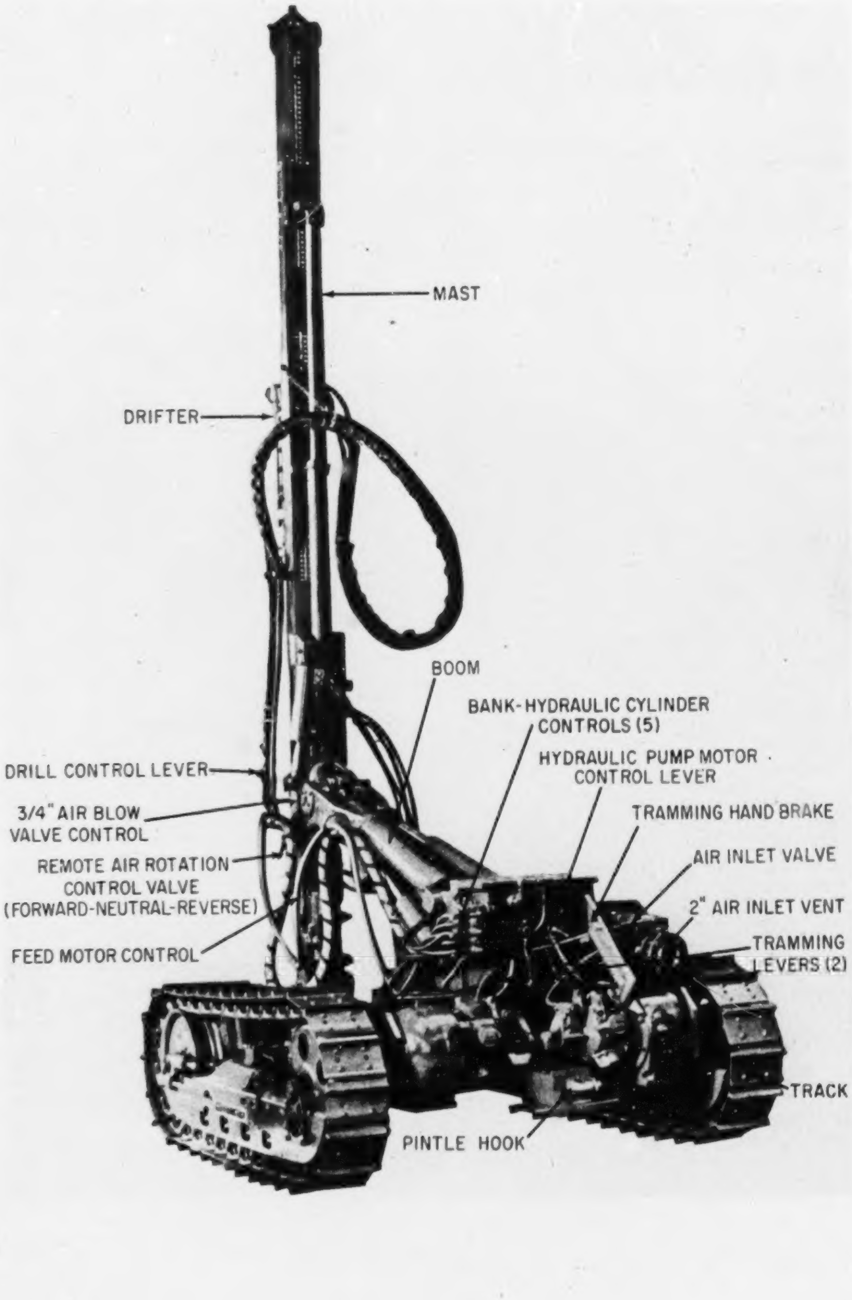

MAST
DRIFTER
BOOM
BANK-HYDRAULIC CYLINDER CONTROLS (5)
HYDRAULIC PUMP MOTOR CONTROL LEVER
DRILL CONTROL LEVER
TRAMMING HAND BRAKE
3/4" AIR BLOW VALVE CONTROL
AIR INLET VALVE
REMOTE AIR ROTATION CONTROL VALVE (FORWARD-NEUTRAL-REVERSE)
2" AIR INLET VENT
FEED MOTOR CONTROL
TRAMMING LEVERS (2)
TRACK
PINTLE HOOK

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Figure 15-14.—Crawler-mounted rock drill.

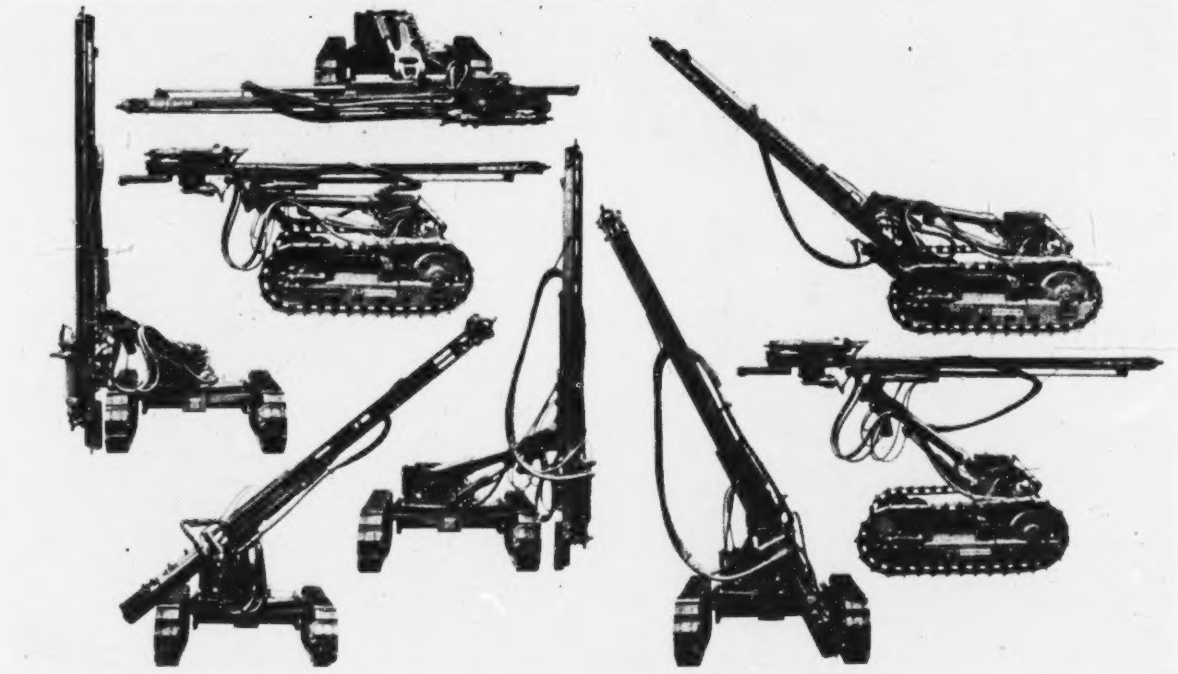

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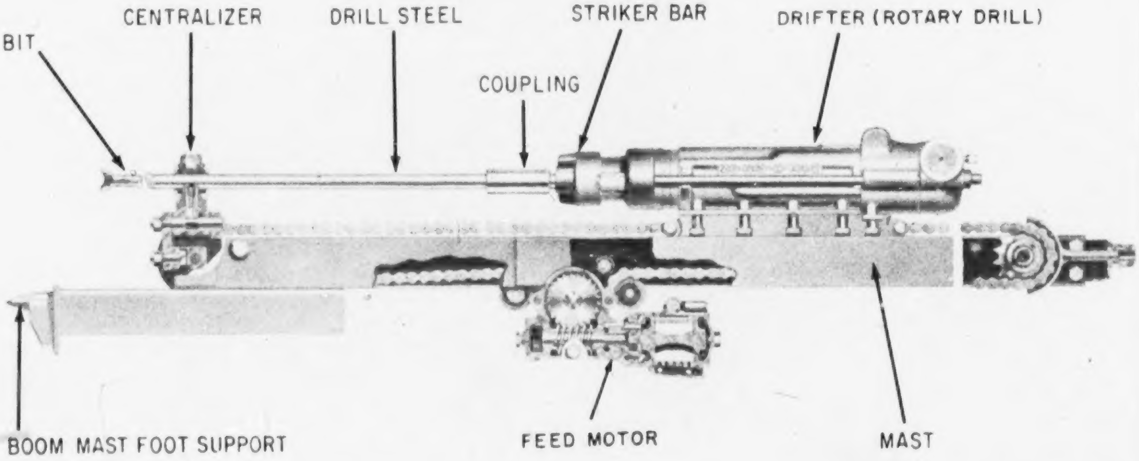
Figure 15-15. — Crawler-mounted rock drill positions.



115.388X

Figure 15-16. — Mast and drifter assembly for crawler-mounted rock drill.

may need to work the steel up and down with some rotation of the drill to facilitate chip removal.

3. When a section of drill is working, run it up and down with the air blow working to give the drill hole extra cleaning action.

4. Never reverse rotation except for coupling action; when doing so, use extreme caution.

5. When working on slopes, make sure, before moving the drill to another location, that you lower the mast to help create a low center of gravity—or you could tip the drill.

LUBRICATION

Careful attention must be given to the lubrication of crawler-mounted rock drills. It is important to use quality lubricants recommended by the manufacturer to ensure maximum performance and minimum down-time for repairs. Lubrication intervals are normally based on an 8-hour workday, intermittent or continuous duty. For multiple shifts per day, lubrication schedules should be altered accordingly.

Oils which are used in the hydraulic systems perform the dual function of lubrication and transmission of power. Select oils with care and only those recommended by the manufacturer or those which meet Navy specifications.

During operation, oil is required to protect the drill steel and bronze drill parts against wear, corrosion, and mineral acidity. The oil reservoir should be checked every 8 hours and the reservoir, as well as the air line system, cleaned after every 500 hours of operation.

Use coupling greases, formulated specially for impact drill steel couplings, which will not melt when high temperatures are reached. Coupling grease prevents the coupling and drill steel threads from "welding" together. If the threads "weld" together, detaching threads is difficult and the location of the "weld" creates a stress point from which drill steel failure starts.

Use an adequate amount of grease and regrease the couplings. If only one drill steel is being used, the threads should be regreased periodically. Do not allow the drill steel thread and coupling to become overheated. If the drill oil coming down the shank piece to the coupling smokes when it runs down the coupling or the coupling changes color, temperatures are being encountered that have affected the coupling and drill steel.

In addition to adequate lubrication, the following measures will extend the useful service life of the drifter:

1. Keep dirt out of the air supply line.
2. Make sure side rods are tightened securely.
3. Discard striking bars that are not square and flat at the striking face and those that are not of correct shank length.
4. Periodically disassemble drifter, inspect, and have worn parts replaced.
5. Be sure the chuck housing cap is always tight.
6. Eliminate moisture in the air lines.

If, after inspection, the drifter needs parts replaced or a more detailed maintenance overhaul, the maintenance section should be contacted.

CRAWLER-MOUNTED ROCK DRILL SAFETY

Many of the safety precautions previously listed for air compressors, power earth augers, and hand-held rotary rock drills also apply to crawler-mounted rock drills. In addition, the following safety precautions must be observed:

Remember to retract the foot of the feed assembly from the drilling face prior to moving the drill rig. Failure to do so will result in breakage of the tilt cylinder piston rod and damage the mast and boom head assembly.

Never use reverse rotation of the drill to break tight or stuck coupling joints.

When uncoupling a string of steel, always close the centralizer arms below the coupling before removing the upper section steel.

Do not operate drill with coupling resting on the centralizer arms.

Do not move drifter rotation control lever from forward to reverse without first stopping the drill as damage may occur.

Exercise extreme care when walking alongside of the rig while tramming. The propelling motors are fast acting, especially in starting and turning.

Avoid fouling or damaging the airhoses when drilling in the "toe-hole" position; the airhoses should rest on the ground.

Never allow the rig to operate without lubricating oil in the reservoir. Lack of lubricant will ruin the air-operated motors and drifter.

CHAPTER 16

PAVING EQUIPMENT AND OPERATIONS

This chapter provides information and guidance for the Equipment Operator engaged in, or responsible for, bituminous and expedient surfacing operations involving roads and airfields. It includes information on construction materials, mix design, equipment, production, placement, repair and maintenance of bituminous and expedient (emergency make shift construction using the natural resources available) surfaces.

Information on starting, operating, and maintaining concrete transit trucks is given in this chapter. Also included is information on the principles of operating asphalt pavers, asphalt distributors, asphalt traveling plants, asphalt kettles, and self-propelled soil stabilization mixers.

Safety precautions must be rigidly observed in paving operations, particularly in the use of flammables. Safety precautions will be noted at pertinent points, where applicable, throughout the chapter.

PAVING CONSTRUCTION

Modern paving is broadly divided into RIGID paving and FLEXIBLE paving. Both types consist of AGGREGATE (sand, gravel, crushed stone, and the like), bound together by a hardening or setting agent called a BINDER. The chief difference between the two types of paving, from the standpoint of ingredients used, lies in the character of the binder.

The binder for most rigid paving is PORTLAND CEMENT, and, for this reason, rigid paving is often referred to as CONCRETE paving. In flexible paving, the binder consists of BITUMINOUS material.

Asphalt paving mixes may be produced from a wide range of aggregate combinations, each having its own characteristics and suited to specific design and construction uses. Aside from the asphalt content, the principal characteristics of the mix are determined, in the main, by the relative amounts of aggregates. The aggregate composition may vary from a coarse-textured mix having a predominance of coarse aggregate to a fine-textured mix having a predominance of fine aggregate.

The selection of a particular bituminous material depends upon the type of pavement, temperature extreme, rainfall, type and volume of traffic, and type and availability of equipment. In general, hard penetration grades of asphalt cement are used in warm climates and softer penetration grades in cold climates. Heavier grades of asphalt cutbacks and tars are generally used in warm regions. Asphalt cements are generally more suitable for high traffic volumes than cutbacks. Asphalts and tars will not necessarily bond to each other; thus, bonding becomes a consideration in bitumen selection.

Looking at figure 16-1 you can see that many types of products, including asphalt materials, are produced by the refining of petroleum. Such asphalt is produced in a variety of types and grades ranging from hard brittle solids to almost water thin liquids. The semisolid form, known as asphalt cement, is the basic material.

Liquid asphaltic products are generally prepared by cutting back or blending asphalt cements with petroleum distillates or by emulsifying them with water. Types of liquid asphaltic products as shown in figure 16-2.

Table 16-1 indicates various uses of asphalt for different types of construction.

In a combat area, expedient materials and methods may be used when men, materials, equipment, or time are not available for more permanent surfacing construction. With the choice of materials or methods, the determining factors in selecting the type of expedient will be the time allotted for construction, the required permanency, the type of terrain, and the anticipated type of traffic. As an expedient, any material or method that will provide a temporary road or airfield may be used. Expedient pavements and surfaces may be used provided the criteria for

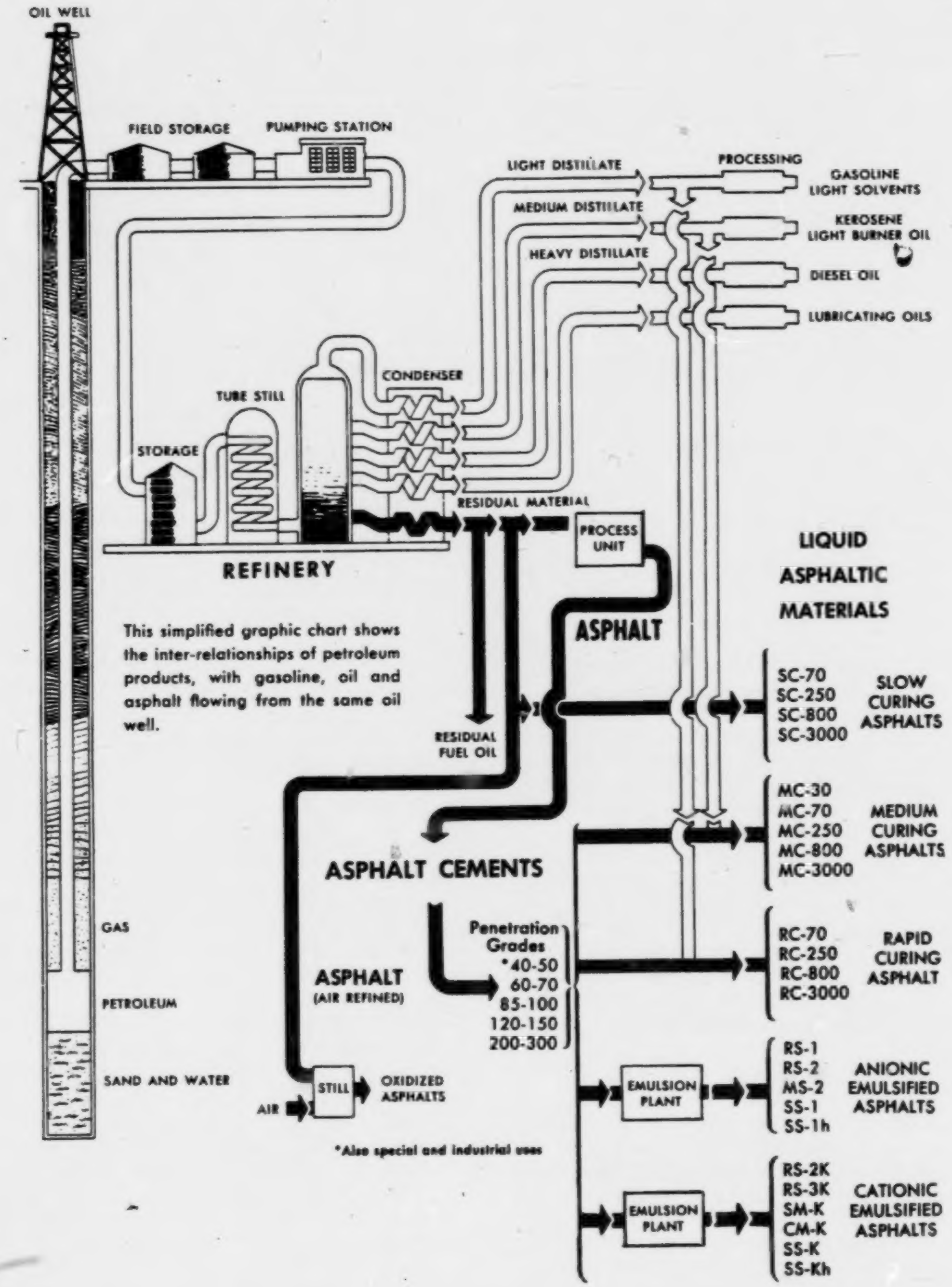


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Figure 16-1. — Petroleum asphalt flow chart.

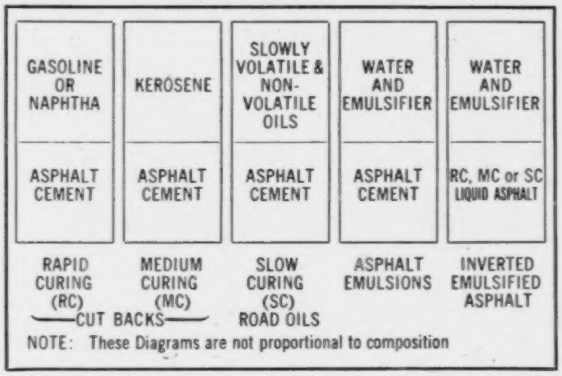

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Figure 16-2.—Liquid asphaltic products.

establishing suitable bases have been met. Sound construction principles and imagination will lead to many improved expedient methods.

ROAD-MIX PAVEMENTS

Road-mix pavements consist of mineral aggregate and mineral filler uniformly mixed in place with a bituminous material and compacted on a prepared base course or subgrade. A single layer, about 1-1/2 inches to 3 inches thick, is generally used. This type of pavement is likely to become defective unless it has a sound, well-drained subgrade and is well mixed, uniformly spread, and properly compacted. Road-mix pavements may be used as a wearing surface on temporary roads and airfields, and as a bituminous base or binder course in construction of more permanent-type roads and airfields. Road mix is an economical method of surfacing small areas when aggregate can be used from the existing base, or when satisfactory aggregate is nearby.

For road-mix pavements, the grade and type of bituminous material depend upon the aggregate and equipment available, as well as weather conditions and time required to complete the project. Good weather is important to the success of a road-mix project. Where possible, road mixing operations should be scheduled when weather conditions are likely to be hot and dry during, and for sometime after, the project. Recommended types of bituminous materials suitable for road mix are asphalt cutbacks, asphalt emulsions, and road tars. A medium-curing cutback is generally used in a moderate climate; and a rapid-curing cutback may be satisfactory for cold climates. Viscosity required is determined by the temperature, aggregate graduation, and method of mixing. The highest viscosity that will completely and uniformly coat the particles of aggregate should be used. In general, open-graded aggregate requires a high viscosity; a gradation containing mineral filler requires a less viscous grade.

Aggregate used in road mix may be scarified from the existing subgrade or hauled in from a nearby source. A wide range of coarse and fine aggregate and mineral filler may be used. The ideal aggregate for road-mix pavement is a well-graded (dense or open) sandy gravel or clean sand. Maximum size of the aggregate, in general, is limited to two-thirds of the compacted thickness of the layer. Loose thickness is approximately 1-1/4 times desired compacted thickness.

Surface moisture is defined as "the film of water around each particle of stone or sand." The amount is determined by heating a weighted sample of aggregate at 212°F in an open pan and stirring with a rod until the surface water disappears (3 to 10 minutes). The difference between the original and final weights is considered to be moisture loss during drying. The loss in weight, expressed as a percent of the final or dry weight, is the moisture content allowed before the aggregate is mixed with asphalt cutbacks or road tars. If the aggregate is too wet, it should be worked with mechanical mixers, graders, or improvised plows to allow the excess moisture to evaporate. For cutbacks and tars, moisture content of coarse-graded aggregate should not exceed 3 percent, and of fine-graded aggregate, 2 percent. For emulsions, moisture content of coarse-graded aggregate should not exceed 5 percent, and of fine-graded aggregate, 3 percent.

Quality of the road-mix pavement depends largely upon the control of the mix. The percentage of bitumen will vary in relation to the absorptive quality of the aggregate, rate of evaporation of the volatile substances, and other factors. Although an exact formula is difficult to follow, proportioning must be controlled within very narrow limits to assure the stability and life of the mix. With dense-graded aggregates especially, too much bitumen should not be used. All particles of the completed mix should be coated and uniform in color. If the mix is too lean, the aggregate in the windrow will stand almost vertically and have a dull

Table 16-1.—Recommended Uses of Various Asphalt Grades

TYPE OF CONSTRUCTION		PAVING ASPHALTS					LIQUID ASPHALTS																							
							Rapid Curing (RC)				Medium Curing (MC)					Slow Curing (SC)				Emulsified										
																				Anionic					Cationic					
		40-50	60-70	85-100	120-150	200-300	70	250	800	3000	30	70	250	800	3000	70	250	800	3000	RS-1	RS-2	MS-2	SS-1	SS-1h	RS-2K	RS-3K	SM-K	CM-K	SS-K	SS-Kh
ASPHALT CONCRETE AND PLANT MIX, HOT LAID																														
Highways			x	x	x										x				x											
Airports			x	x																										
Parking Areas			x	x																										
Driveways			x	x																										
Curbs			x	x[1]																										
Industrial Floors		x																												
Blocks		x																												
PLANT MIX, COLD LAID																														
Graded Aggregate														x				x					x						x	x
ROAD MIX																														
Open-graded Aggregate								x	x					x	x							x						x		
Dense-graded Aggregate								x	x				x	x			x	x				x	x				x		x	
Clean Sand								x	x				x	x										x					x	x
Sandy Soil							x	x	x				x	x			x	x					x				x		x	x
PENETRATION MACADAM																														
Large Voids				x					x	x											x					x				
Small Voids					x			x												x					x					
SURFACE TREATMENTS																														
Single, Multiple and Aggregate Seal					x	x		x	x	x			x	x	x					x	x		x		x	x			x	
Sand Seal								x	x				x	x						x			x	x	x				x	x
Slurry Seal																							x	x					x	x
Fog Seal																							x[2]	x[2]					x[2]	x[2]
Prime Coat, open surfaces								x					x																	
Prime Coat, tight surfaces							x				x	x				x														
Tack Coat							x													x			x[2]	x[2]	x				x[2]	x[2]
Dust Laying											x	x				x							x[2]						x[2]	
PATCHING MIX																														
Immediate Use													x					x												
Stock Pile													x	x			x	x									x	x		
HYDRAULIC STRUCTURES																														
Membrane Linings, Canals & Reservoirs		x[3]																												
Hot Laid, Graded Aggregate Mix for Groins, Dam Facings, Canal & Reservoir Linings		x	x																											
CRACK FILLING							x													x			x[4]	x[4]	x				x[4]	x[4]
MEMBRANE ENVELOPE		x	x																											
EXPANSION JOINTS		Blown asphalts, mineral-filled asphalt cements, and preformed joint compositions																												
UNDERSEALING PCC		Blown asphalts																												
ROOFING		Blown asphalts																												
MISCELLANEOUS		Specially prepared asphalts for pipe coatings, battery boxes, automobile undersealing, electrical wire coating, insulation, tires, paints, asphalt tile, wall board, paper sizing, waterproofing, floor mats, ice cream sacks, adhesives, phonograph records, tree grafting compounds, grouting mixtures, etc.																												

In northern areas where rate of curing is slower, a shift from MC to RC or from SC to MC may be desirable. For very warm climates, a shift to next heavier grade may be warranted.

[1] *In combination with powdered asphalt.*

[2] *Diluted with water.*

[3] *Also 50-60 penetration blown asphalt and prefabricated panels.*

[4] *Slurry mix.*

115.406

look while if too rich, it will ooze or slip out of shape. If the mix is correctly proportioned, a handful squeezed into a ball will retain its shape when the hand is opened.

Road-mix pavements should be constructed only on a dry base when the weather is not rainy. Atmospheric temperature should be above 50°F. Mixing should take place at the temperature of the aggregate, but not below 50°F or above the recommended temperature of the liquid asphalt being used. The construction procedure depends upon whether the base is a newly constructed base, a scarified existing base, or an existing pavement.

If a newly constructed base is used, apply the following procedure:

1. Inspect and condition the base.
2. Prime the base and allow the prime to cure.

3. Haul in and windrow the aggregate at the side of the primed base (allow the aggregate to dry or aerate with blade if wet.)
4. Spread the aggregate on the cured prime base 1/2 road bed width.
5. Spray the bitumen on the aggregate in increments of about one-third the total amount required.
6. Mix the bitumen with the aggregate, blade back and forth until a uniform mix is obtained.
7. Repeat as directed in (5) and (6) until thoroughly mixed.
8. Spread the mix to the specified thickness.
9. Compact the surface.
10. Apply a seal coat if necessary.

For a scarified base, the aggregate is scarified if it is not available from other sources. The construction procedure is as follows:

1. Loosen the aggregate from the base.
2. Dry and break up all lumps of material.
3. Blade into parallel windrows of uniform size and one side and/or in the center.
4. Sweep the base, if needed.
5. Prime the base and allow time to cure.
6. Continue as directed in (4) through (10) in the above procedures for a newly constructed base.

If an existing pavement is to be used as a base, the construction procedure is:

1. Sweep the base.
2. Apply a tack coat and allow it to cure.
3. Bring in the aggregate and deposit in windrows at the side of the cured, tacked base.
4. Aerate the aggregate.
5. Spread the aggregate on 1/2 the tacked base.
6. Spray bitumen on the aggregate in increments of about 1/3 the total amount required.
7. Mix the bitumen with the aggregate, by blade.
8. Spread the mix to specified uncompacted thickness.
9. Compact the surface.
10. Apply a seal coat if necessary.

When mixing in place (road mix), here are some helpful hints:

1. Do not buck nature — stop operations when working under adverse weather conditions.
2. Keep the mixture or aggregate in a well packed windrow for better water shedding and control.
3. Provide drainage cuts through the windrow during heavy rains.
4. When a motor grader comes to the end of a section with a full blade, lift it rapidly, to avoid carrying materials into the next section.
5. The distributor spray must be cut sharply at sectional joints; carry-over to the next section will cause undesirable fat joints.
6. Plan the work to avoid inconvenience to traffic.
7. Apply the asphalt at the recommended spraying viscosity to ensure uniform application.
8. A shoe on the outer end of the grader blade or moldboard helps obtain a good edge during spreading operations.
9. Aggregate in shaded areas usually requires extra aeration.

ROAD MIXING METHODS

Three methods of road mixing that the Equipment Operator may use in expedient surfacing operations for roads and airfields are travel plant mixing, blade mixing, and soil asphalt stabilization mixing. These methods are discussed separately below.

Travel Plant Mixing

When a travel plant is used for mixing, the loose aggregate is dumped, mixed, and bladed into uniform windrows, and evened if necessary. The windrow should be sufficient to cover the section of the area to be paved with enough loose material to give the desired compacted depth and width. As the bucket loader tows the mixer and elevates the aggregate to the mixer hopper, the mixer meters the aggregate, sprays it with the correct amount of bitumen, mixes these two uniformally and redeposits the mix into another windrow behind the plant. The rate of travel and the mixing operation should be controlled so that all particles of the aggregate are coated and the mix is uniform. Accuracy in proportioning the mix is extremely important.

The travel plant method usually produces a more uniform mix of higher quality than blade mixing. Heavier types of asphalt cutback and tar may be used. This reduces the time required for curing. The asphalt finisher may be used concurrently with the travel plant. The hopper of the finisher is kept directly under the travel plant output chute. This arrangement reduces

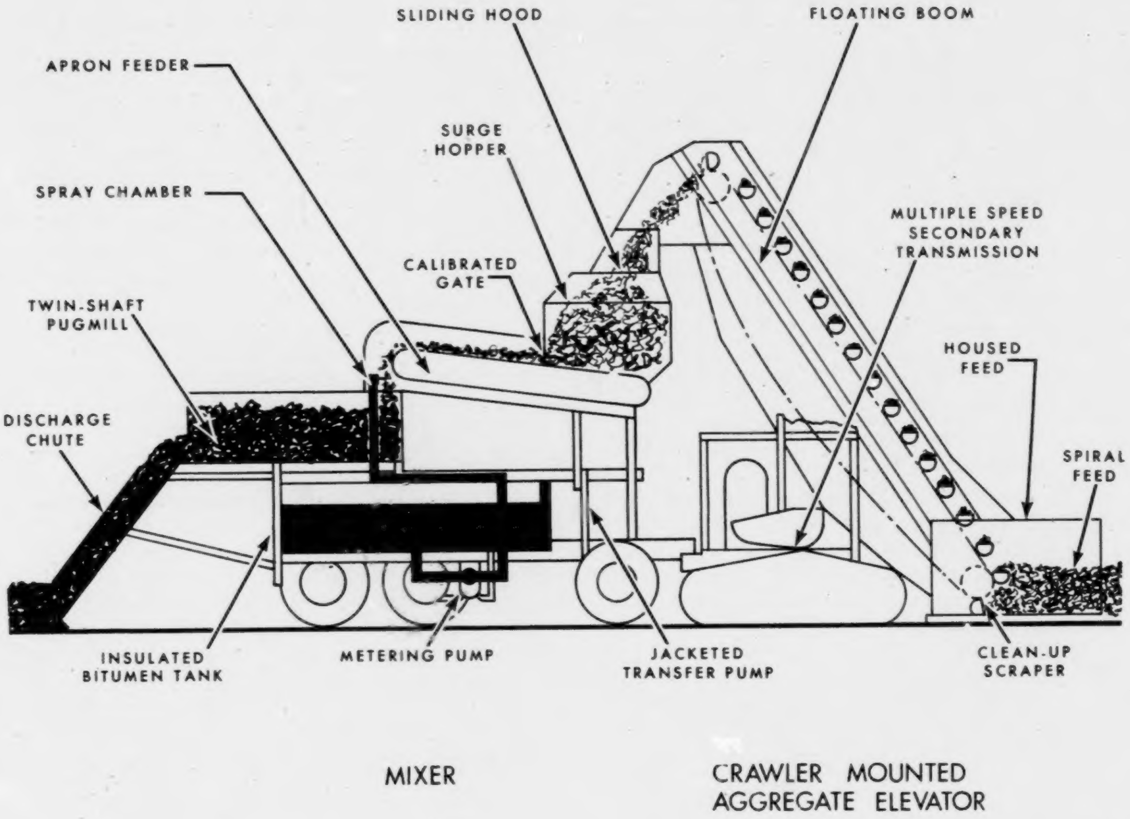

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Figure 16-3. — Schematic layout of a travel plant.

the maximum output of the plant, although it does provide for uniform thickness of the mat being laid.

Windrows must contain no more material than the finisher can place. The major advantage of this setup is that in-place aggregate may be used in an intermediate mix and placed with a finisher without the necessity of loading and transporting aggregate. The finisher must be used with the travel plant for construction of some airfields where surface tolerances are critical. Figure 16-3 shows a schematic view of a travel plant.

Blade Mixing

In blade mixing, the aggregate is dried and bladed into windrows. The windrows are then flattened and bitumen of the specific temperature is applied with a bituminous distributor in three equal applications. Each application is 1/3 the amount required.

Immediately following each application of the bituminous material, the treated aggregate should be mixed with springtooth or double-disk harrows, motor graders, rotary tillers, or a combination of this equipment, until all the particles of the aggregate are evenly coated. When motor graders are used, the windrow is moved from side to side by successive cuts with the blade.

Several graders can operate, one behind the other, to reduce the total time required for complete mixing. In hilly terrain, blading should be from the bottom to the top as the mix tends to migrate down. After all the aggregate has been mixed, the mix should be bladed into a single windrow at or near the center of the road, and turned not less than four complete turns from one side of the road to the other. Excess bitumen, deficiency of bitumen, or uneven mix should be corrected by the addition of aggregate or bituminous material, followed by remixing. Mixing should continue until it is complete and satisfactory; remember, mix will set up if mixed too long.

Suppose that materials, weather conditions, and equipment are well suited to mixed-in-place paving, but the road or airfield must carry traffic during construction. In such cases, the windrowing of aggregate and the mixing and spreading of bitumen may be done elsewhere, on any area of smooth ground which can be compacted for the purpose, or on any unused road or airfield surface. The road or airfield surface, base, or subbase to be paved is then primed or tack coated as required to complete construction and keep portions of the road or airfield open to traffic. As soon as the prime or tack coat cures the mix is picked up, trucked to the jobsite, dumped, and then bladed into windrows for spreading.

The bituminous mix should not be spread when the surface is damp, or when the mix itself contains an excess of moisture. The mixed material should be spread to the required width in thin, equal layers by a self-propelled motor grader or finisher. (If a finisher is used, additional support equipment is required, and the material must be split into two windrows for an 8- to 12-foot wide pavement.) When spreading the mix from a windrow, care should be taken to prevent cutting into the underlying subgrade or base course. If necessary to prevent such cutting, a layer of mix, approximately 1/2-inch thick, may be left at the bottom of the windrow.

The material being spread should be rolled once, and then leveled with a motor grader to remove irregularities. Remaining material should then be spread and rolled in thin layers, until the entire mix is evenly spread to the depth and width specified. During the spreading and compacting, the surface should be dragged or bladed, as necessary, to fill any ruts and to remove corrugations, waves, or other irregularities. Both pneumatic-tired and steel-wheeled rollers may be used for rolling on all surface treatment jobs; however, the pneumatic-tired roller is the preferred type. While the pneumatic-tired roller will give uniform pressure over the entire area the steel-wheeled roller will hit only the high spots. In any case, two self-propelled rollers should be used with each surface treatment job.

After all layers have been satisfactorily spread, the surface should be rolled with two-axle tandem rollers. Rolling should begin at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the wheel of the roller. Alternate trips of the roller should be different lengths. The speed of the roller at all times should be controlled to avoid displacement of the mix. Light blading (or floating) of the surface with the motor grader during rolling may be required. Rolling should be continued until all roller marks are eliminated, and maximum density obtained. To prevent adhesion of the mix to the roller, the roller wheel should be kept moist with water; use only enough water to avoid picking up the material. The rollers should be in good condition, suitable for rolling asphalt, and should be operated by trained roller operators. At all places not accessible to the roller, the mix should be thoroughly tamped with hand tampers. If the surface course becomes rough, corrugated, uneven in texture, water-soaked, or traffic marked, unsatisfactory portions should be torn up, and reworked, relaid, or replaced. When forms are not used, and while the surface is being compacted and finished, the outside edges should be trimmed neatly in line.

If the road-mix pavement surface course is constructed from an open-graded aggregate, a surface treatment may be required to waterproof the surface. A surface treatment is unnecessary on a dense-graded, well-compacted, road-mix pavement.

Where possible, traffic should be kept off of freshly sprayed asphalt or mixed materials. If it is necessary to route traffic over the new work, speed must be restricted to 25 m.p.h. or less until rolling is completed and the asphalt mixture is firm enough to take high speed traffic.

Soil Asphalt Stabilization Mixing

Soil asphalt stabilization requires a mixture of pulverized soil and bituminous material. By the addition of bituminous material, many soils, which in their natural state would be too unstable for use as a base course, can be made to serve satisfactorily as a base course. The bituminous material serves primarily as a waterproofing agent rather than a binding agent; however, the bitumen does have some binding value.

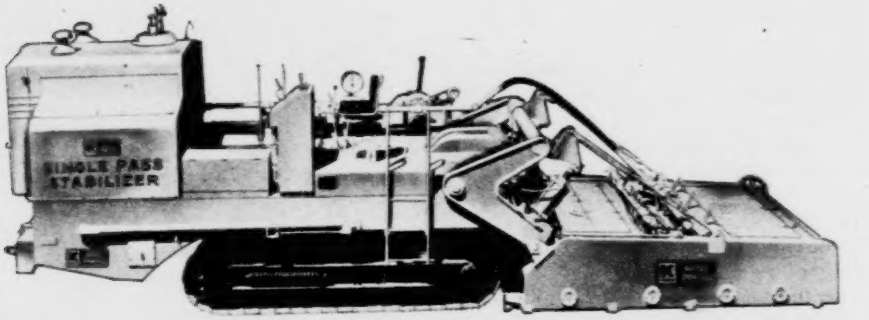

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Figure 16-4. — Multi-shaft, single-pass soil stabilizer.

If properly constructed, soil asphalt stabilization generally forms an excellent base. However, it is too friable to withstand the abrasive action of traffic, wears rapidly, and often develops uneven surfaces that eventually cause pot holes. Soil asphalt stabilization is recommended only as a base course, on which there is to be placed an approved type of wearing course or surface treatment.

Since most multiple-shaft, single-pass soil stabilization mixing machines such as that shown in figure 16-4 have a high-speed pulverizing rotor, preliminary pulverization is usually unnecessary. The only preparation required is to dig a trench about 18 inches wide and to the depth to be processed (1/4 inch minimum to 8 inches maximum) and across the full width of the roadway to be stabilized. Material removed from this trench should be spread out uniformly over the roadway so that this material will be mixed as the mixing box of the stabilizer unit travels forward.

Processing is done in lanes from 350 to 900 feet depending upon the rate of processing, with a width equal to that of the stabilizing machine. The stabilizing mixer is positioned in the first lane at the point where the cutting rotor is directly above the trench or starting point.

With the bituminous tank truck coupled to the front of the stabilizer, the suction hose connected to the delivery pump, and the mixer moving forward, the high speed cutting rotor cuts and pulverizes the road material to be stabilized. The blending rotor picks up the loose material and trims the subgrade. Turning in the opposite direction of the cutting rotor, the blending rotor provides a shuttle motion that ensures a thorough mixing of the material. The material from the blending rotor is then carried up and over the rotor and tossed into the twin pugmill. While the material is still in mid-air, it passes through an atomized spray of asphalt liquid. The strategic placement of the spray bars, together with controlled pressures, provides the most efficient dispersion of liquid for assuring accurate, uniform coating of all material particles.

All asphalt liquids used in material processing are accurately metered. After passing through the asphalt liquid spray, the thoroughly coated materials are agitated in a transverse, twin pugmill with overlapping blades. The opposed action of the blades provides intensified agitation and squeezing. This important operation renders a thorough job of final mixing and prepares the uniformly mixed mass of materials for subsequent spreading.

The adjustable tailgate provides flexibility for regulating the amount of materials held in the pugmill for thorough mixing and conforming to the processing depth. It strikes off materials to a uniform loose density the full width of the processing chamber. This material is then ready for immediate compaction where aeration is not required.

A small asphalt liquid tank on the machine permits continuous operation while the asphalt tank truck is being switched. The gallons of liquid asphalt required for a soil asphalt stabilization project will be determined by the project supervisor.

BITUMINOUS MATERIALS

Pavements constructed of bituminous materials and aggregates are referred to as "flexible pavements," because of their ability to permit slight deflections without detrimental effect. Flexibility is due to consolidation of the base course or effect of a load. Flexible pavements provide a resilient, waterproof, load-distributing medium which protects the base course from the detrimental effect of water and the abrasive action of traffic. Properly designed, high quality bituminous concrete is affected very little by temperature strains and fatigue stresses. Bituminous concrete pavements are subject to nominal maintenance due to wear, weathering, and deterioration from aging. Also, as load intensities increase, additional layers of bituminous pavement can be added to existing pavement to provide further reinforcement.

Bituminous pavements can be placed easily and quickly. For these reasons, bituminous materials have become of tremendous importance to both the military and civil engineer in the construction of roads and airfields. They can be used not only in pavements but also as soil stabilizers, thereby improving the strength and waterproofness of subgrades, subbases, and base courses.

Tack Coat

A tack coat is an application of asphalt to an existing paved surface to provide bond between the existing surface and the asphalt material to be placed on it. Two essential requirements of a tack coat are: (1) it must be very thin, and (2) it must uniformly cover the entire surface to be treated. A very thin tack coat does no harm to the pavement and it will properly bond the course.

Some of the bituminous materials used for tack coats are rapid-curing cutbacks, road tar cutbacks, rapid-setting emulsions (may be used in warm weather), and medium asphalt cements. Because rapid-curing cutbacks are highly flammable, safety precautions must be very carefully followed.

A tack coat should be applied only when the surface to be tacked is dry and the temperature has not been below 35°F for 12 hours immediately prior to application.

Before applying the tack coat to a surface that is sufficiently bonded, see that all loose material, dirt, clay, or other objectionable materials are removed from the surface to be treated. This operation may be accomplished with a power broom or blower, supplemented with hand brooms if necessary.

Immediately following the preparation of the surface, the bituminous material should be uniformly applied by means of a bituminous distributor (discussed later in this chapter) at the spraying temperature specified. The amount of bitumen application varies with the condition of the existing pavement being tack-coated, but in general 0.10 to 0.25 gal per sq yd is satisfactory. Following the application of bituminous material, the surface should be allowed to dry until it is in a proper condition of tackiness to receive the surface course, otherwise the volatile substances may act as a lubricant and prevent bonding with the wearing surface. Clean, dry sand should be spread on all areas that show an excess of bitumen to effectively blot up and cure the excess.

An existing surface that is to be covered by a bituminous wearing surface should be barricaded to prevent traffic from carrying dust or mud onto the surface, either before or after the tack coat is applied. Should it become necessary for traffic to use the surface, one lane may be tack coated and paved, using the other lane as a traffic bypass. The bypass lane should be primed and sanded before opening to traffic. It should be swept and reprimed after the adjacent lane is completed. This preserves the base and acts as a dust palliative (sheltering).

Prime Coat

Priming consists of the initial treatment on a granular base prior to surfacing with a bituminous material or pavement. The purpose of a prime coat is to penetrate the base (about 1/4" minimum penetration is desired), fill most of the voids, promote adhesion between the base and the bituminous applications placed on top of it, and waterproof the base.

The priming material may be either a low viscosity tar, a low viscosity asphalt, or a diluted asphalt emulsion. The quantities of priming materials to be applied will be determined by the condition of the soil base and climate. The use of rapid-curing asphalt cutbacks, in general 0.2 to 0.5 gal per square yard, in cold climates has proved to be satisfactory. However, the prime coat can be eliminated if the climate is very cold, as this is likely to slow the curing process.

The sequence of operations for the application of a prime coat is the same as described earlier for application of a tack coat. If the base absorbs all of the prime material within 1 to 3 hours, or if penetration is too shallow, the base is underprimed. Underpriming may be corrected by applying a second coating of the prime material.

An overprimed base may fail to cure and contribute to failure of the pavement. A free film of prime material remaining on the base after a 48-hour curing period indicates that the base is overprimed. This condition may be corrected by spreading a light, uniform layer of clean, dry sand over the prime coat to absorb the excess material. Application of the sand is usually followed by light rolling and brooming. Excess prime held in minor depressions should be corrected by an application of clean, dry sand. Any loose sand should be lightly broomed from the primed surface before the wearing surface is laid.

The primed base should be adequately cured before the wearing surface is laid. In general, a minimum of 48 hours should be allowed for complete curing. Ordinarily, proper surface condition is indicated by a slight change in the shiny black appearance to a slightly brown color.

When a soil base is to be covered by a bituminous wearing surface, the area should be barricaded to prevent traffic from carrying dust or mud onto the surface both before and after priming. If it is necessary to open the primed base course to traffic before it has completely cured, a fine sand may be used; and when ready to place the wearing surface, lightly broom the sand from the primed base course.

Single and Multiple Surface Treatments

A single surface treatment usually consists of a sprayed application of a bitumen and aggregate cover one stone thick. Surface treatment may be referred to as a seal coat, inverted penetration, armor coat, or carpet coat. A single surface treatment is usually less than 1/2 inch thick. Surface treatments serve as an abrasive and weather-resisting medium which waterproofs the base. Generally, they are not as durable as bituminous concrete and may require frequent maintenance. Surface treatments are particularly suitable for surfacing aged or worn bituminous pavements that are cracked, dry, reveled, or beginning to show signs of wear. When bituminous pavements are designed and constructed properly, they should possess a surface texture that does not require surface treatment to fill the voids.

Surface treatments are used largely on roads, shoulders, and parking areas. Although not recommended for airstrips, they may be used as an expedient measure. Surface treatments are particularly suitable for Naval Construction Force construction because they may be laid quickly with a minimum of materials and equipment, they may be constructed in multiple layers with little interference to traffic, and they may be used as the first step in forward area construction. Surface treatments will not withstand the action of metal wheels on vehicles, tracked vehicles, or non-skid chains on vehicle wheels. Surface treatment should not be attempted except when the temperature is above 50°F. Three requirements for a surface treatment are:

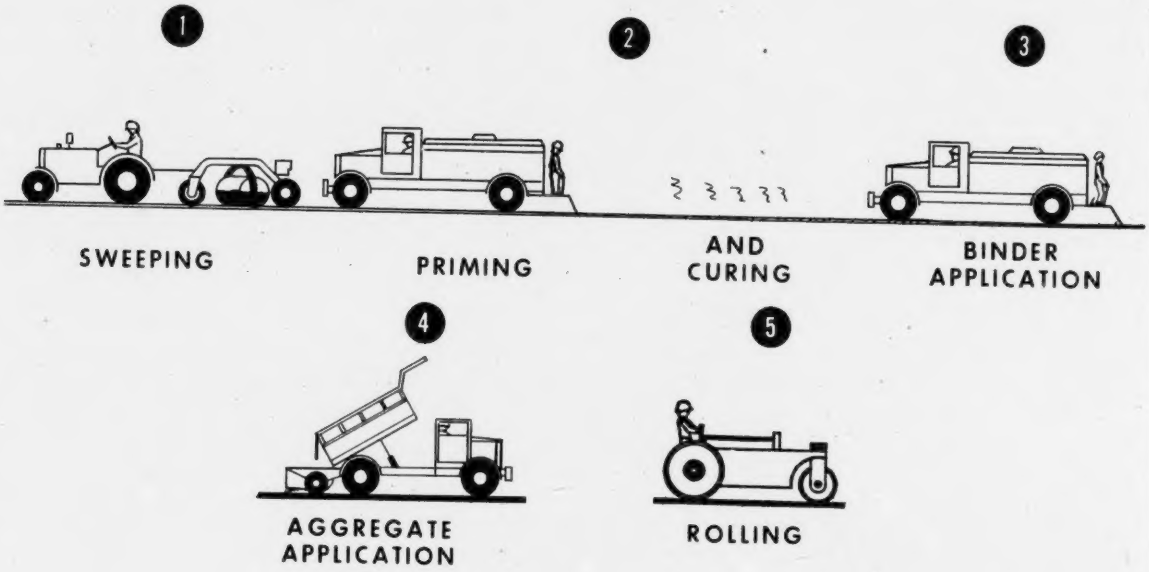
1. The quantity of the bitumen must be sufficient to hold the stone without submerging it.
2. Sufficient aggregate must be used to cover the bitumen.
3. The base course on which the surface treatment is laid must be sufficiently strong to support the anticipated load.

A single surface treatment consists of an application of bitumen covered with mineral aggregate, rolled to provide a smooth, even-textured surface. Figure 16-5 shows the sequence of operations for the application of a single surface treatment.

Uniformly graded sand or crushed stone, gravel, or slag may be used for surface treatments. The purpose of the surface treatment determines the size of the aggregate to be selected. For example, coarse sand may be used for sealing a smooth existing surface. For a badly broken surface, the maximum size of the aggregate should be about 1/2 inch, and the mimimum size about 3/16 inch.

Rapid-cure cutbacks, medium-cure cutbacks, road tars, rapid-setting emulsions, and asphalt cements may be used for surface treatment. Rapid-cure cutbacks are most widely used because they evaporate rapidly and the road can be opened to traffic almost immediately after application of the surface treatment.

Surface treatments are usually applied to a thoroughly compacted primed base that has been swept clean. The existing surface or base course



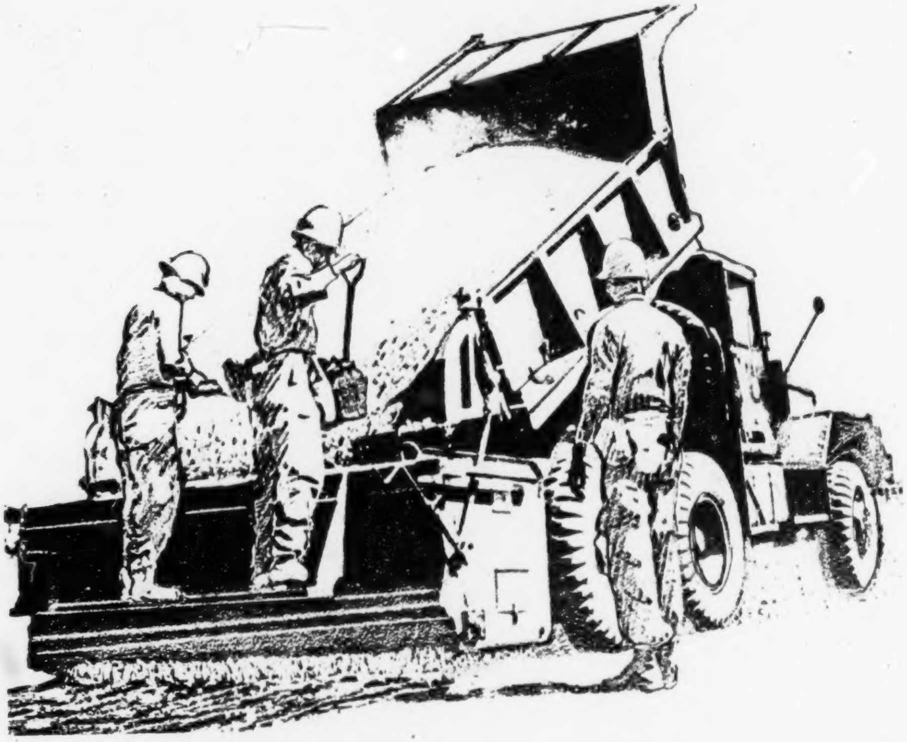
115.396
Figure 16-5.—Sequence of operations for the application of a single surface treatment.

must be dry, or contain moisture not in excess of that which will permit satisfactory bonding of surface treatment to the base. To assure uniform distribution, the bitumen should be applied with a bituminous distributor. The quantity of the bitumen required is based on the average particle size of the coverstone (aggregate). The bitumen must be sufficient to hold the aggregate in place without leaving a sticky surface. The aggregate must not be completely submerged in the bitumen. The viscosity used is dependent upon the size of the coverstone; the larger the coverstone, the higher (or thicker) the viscosity of the bitumen. One-quarter-inch aggregate should be submerged approximately 30 percent; 3/8-inch aggregate, 32 percent; 1/2-inch aggregate, 35 percent; and 3/4-inch aggregate, 43 percent. Approximately 1 gallon of bitumen is usually used for 100 pounds of aggregate.

The aggregate is spread immediately after application of the bitumen, while the bitumen is still fluid. An adjustable mechanical aggregate spreader may be used as shown in figure 16-6, or the aggregate may be spread from trucks or by hand. Trucks should be operated backwards so that the truck wheels will move over the bitumen that has been covered with aggregate. For handspreading, aggregate should be dumped in piles adjacent to the areas to be treated.

During aggregate spreading, the surface is rolled with a 5- to 8-ton roller. A heavier roller is likely to crush the aggregate rather than embed the aggregate particles in the bitumen. Faulty rolling can be eliminated or minimized if the following practices are adhered to:

1. Rolling should be parallel to the centerline of the roadway to reduce the number of times the roller must change direction.
2. To assure complete coverage, succeeding passes should overlap one-half of the wheel width of the roller.
3. Rolling should be completed before the bitumen hardens. This will ensure that the aggregate becomes well embedded in the bitumen.
4. To maintain surface crown and to prevent feathering at the edges, succeeding passes should be made from the low side to the high side of the surface.
5. Rolling should be done at a slow speed.
6. Rolls should be wet to prevent bitumen from sticking to wheels.



115.501

Figure 16-6.—Hopper-type spreader applying aggregate to a surface treatment.

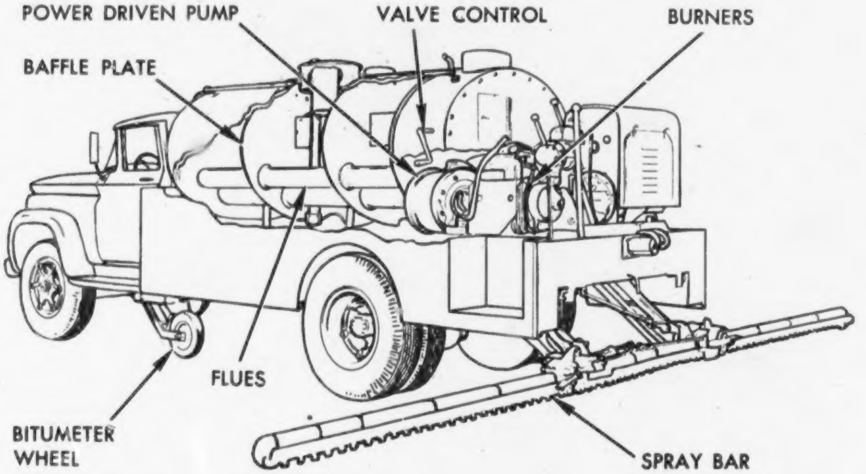
7. The power roll should pass over the unrolled surface before the steering roll.

After rolling and curing, the surface is ready for traffic. If the surface is used on an airfield, excess aggregate must be swept from the surface to avoid damage to aircraft. This practice is also recommended for roads, although it is not essential.

When a tougher, more resistant surface is desired than that obtained with a single surface treatment, multiple surface treatment may be used. Multiple surface treatment is two or more successive layers of a single surface treatment. Smaller particles of aggregate and correspondingly less bitumen are used for each successive layer. Although multiple surface treatments are usually more than 1 inch thick, they are still considered surface treatments because each layer is usually less than 1 inch and the total surface treatment does not add appreciably to the load-carrying capacity of the base.

The first layer of a multiple surface treatment is laid in accordance with instructions given earlier for a single surface treatment.

Loose aggregate remaining on the first layer must be swept from the surface so that the layers may be bonded together. Remember that the size of the aggregate and the bitumen will decrease for each successive layer. For the second layer, the bitumen will usually be reduced one-third or one-half of the amount used in the first application. The aggregate used in the second application should be approximately one-half the diameter of that used in the first application. The final application is drag-broomed, if necessary, to provide an even layer of aggregate. At the time the surface is being drag-broomed, it should also be rolled with a 5- to 8-ton



115.398

Figure 16-7.—Asphalt distributor.

roller so that the aggregate will become embedded in the bitumen. After the surface is rolled and cured, it is ready for traffic. If the multiple surface treatment has been laid on an airfield, loose aggregate must be swept from the surface so that it will not damage the aircraft. Final sweeping is also recommended for roads.

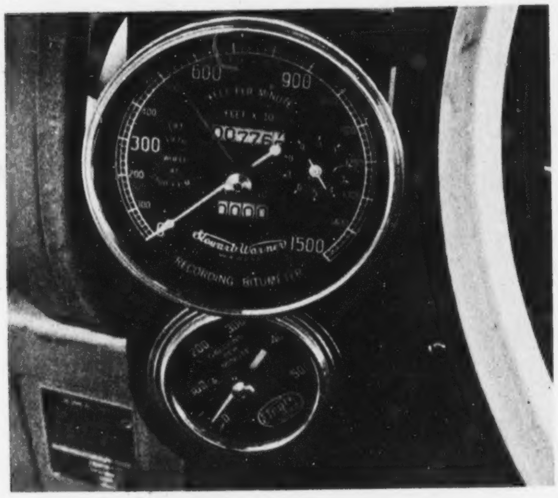
To prevent a soil wearing surface (dirt road) from becoming excessively dusty, a bituminous dust palliative (covering) is applied to hold down the dust. The bituminous material used as a dust palliative must be thin enough to soak easily into the surface. It must also retain fluidity indefinitely so that dust particles raised by the traffic will become coated with the bituminous material. A medium-cure or slow-cure cutback is the best material for this purpose.

ASPHALT DISTRIBUTOR

An asphalt distributor, illustrated in figure 16-7, is frequently used to spray bituminous material on a prepared surface. The insulated bitumen tank is equipped with heating flues for application of heat from an oil burner. A gasoline engine, mounted to the rear of the truck, provides power for an asphalt pump, fuel pump, and air blower. The asphalt pump has an output range from 30 to 350 gallons per minute. The application rate of bitumen is controlled by the width of the spray bar, pump output, and forward speed of the truck after the bitumeter indicator has been set. The spray bar width can vary from 6 to 24 feet in width. The output of bitumen will range from 1/10 to 3 gallons per square yard. Where necessary, bituminous material may be applied through an adjustable length spray bar or a hand spray gun. The spray bar may be of the circulating or noncirculating type, depending upon the model of the distributor. Flow of bituminous material is controlled by a system of hand-operated valves. A tachometer registers the pump discharge in gallons per minute and/or speed of the engine, and a bitumeter shows the forward speed of the truck in feet per minute. (See fig. 16-8.)

When applying asphalt for a prime or tack coat, an over application of asphalt should be avoided. For this reason, each distributor load should be started out over building paper (sometimes called tar paper). This will also prevent transverse overlap of material.

To maintain uniform pressure and temperature on all spray nozzles, the fan of the spray from each nozzle must be uniform and set at the proper angle with the spray bar (according to the manufacturer's instructions) so that the spray fans do not interfere with each other. The spray bar must be maintained at the proper height



115.399
Figure 16-8. — Bitumeter and tachometer dials.

above the road surface to provide complete and uniform overlap of the spray fans. The overlap can vary from 6 to 15 inches depending on the desired coverage and type of distributor used. The road speed must be uniform as determined by the type of surface treatment being applied.

ASPHALT FINISHER

While various makes and models of asphalt finishers are used in asphalt paving operations, the finisher most used by the SEABEES for training and field operations is the Barber-Greene model SA-35 shown in figure 16-9.

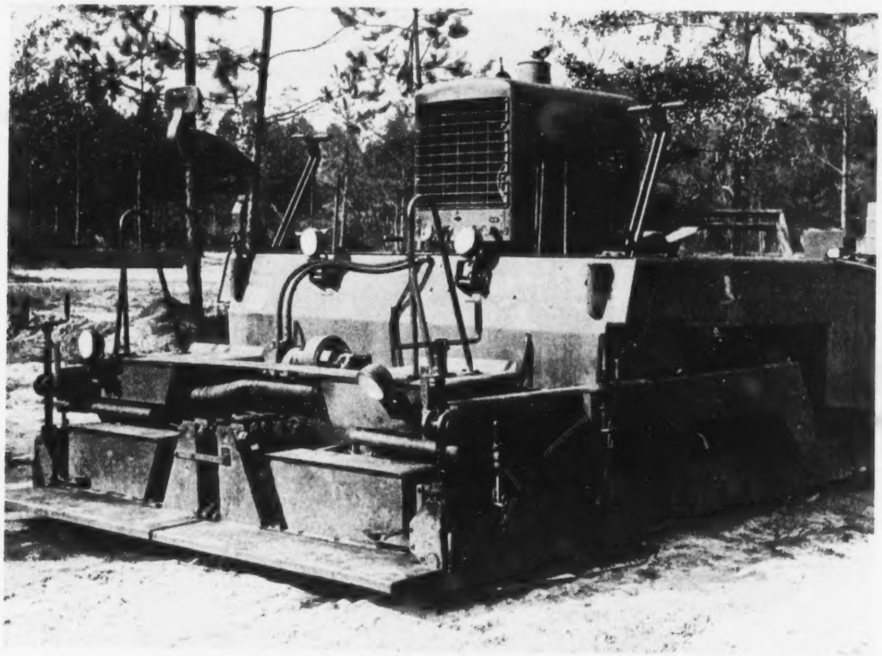
When the surface has been cleaned, primed, and allowed to cure, it is ready for paving. In spreading mix, whether a hot or cold bituminous mixture, an asphalt finisher is used to lay the mixture into a smooth mat of required thickness and width. While the asphalt finisher shown in figure 16-9 is capable of handling up to 200 tons of mix per hour, its effective capacity is 100 tons per hour. The mat width may be varied from 8 to 14 feet, the depth from 1/2 to 6 inches, and the laydown speed from 12 to 64 feet per minute. The finisher consists essentially of a crawler-mounted tractor unit and a screed unit that is attached to the tractor. An 8-ton charging hopper is mounted on the front of the finisher where the mix is dumped from a truck. A bar feeder on the hopper floor moves the mix to the spreading screws, which spread the mix in front of the screed unit. At the front of the screed assembly, a tamper bar strikes off the mat to the desired elevation and compacts it to as much as 85 percent of final density.

As shown in figure 16-10, the forward, beveled edge of the tamper does the compacting, while the lower edge does the striking off. Behind the tamper the screed slides along, giving the mat the final smooth finish.

A burner unit, figure 16-11, permits heating of the screed to prepare it for proper operating temperature. In general, the reason for heating the screed is to keep the asphalt material from sticking to it, and causing what is known as a drag to tear. Thickness of the mat is controlled by two thickness control screws as shown in figure 16-12. The screed may be adjusted at center to produce a crown. Normal width of the screed is 10 feet, but the width may be increased to 14 feet by use of screed extensions, or reduced to 8 feet by use of cutoff shoes. The finisher is usually powered by a gasoline engine, with a diesel engine being optional.

The manually operated dual controls of the model SA-35 finisher allow the operator to sit on the same side of the machine as the guideline or the edge of the existing mat (see fig. 16-13). This feature greatly eases longitudinal joint alignment control. Dual controls are most advantageous for paving in narrow places, such as parking areas and around airfield facilities. Operators may be stationed on both sides in such restricted places, greatly reducing the chance of collision and resulting damage to both the machine and objects nearby. Dual controls also allow operators to be trained in minimum time.

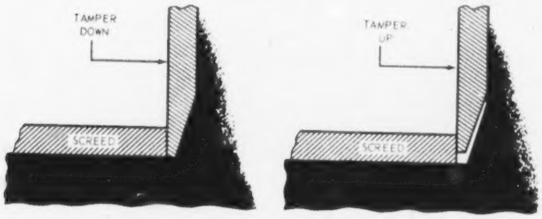
Assuming that the operations ahead of the paver have been properly performed, that the equipment is in good condition and properly adjusted, and that the paver is not placing the mix at an excessive rate of speed, there should be no need for hand work. Hand raking should not be done unless absolutely necessary. The most uniform surface texture can be obtained by keeping the hand work back of the paver to a minimum, except when it is required around obstacles.



115.400

Figure 16-9.—Asphalt finisher.

On many jobs there are places where spreading with a paver is either impractical or impossible. In these cases, hand spreading is required. Placing and spreading by hand should be done very carefully and the material distributed uniformly so that segregation of the coarse aggregate and the bituminous binder will be avoided. If the asphalt mix is broadcast with shovels, almost complete segregation of the coarse and fine portions of the mix will result. The material should be deposited from the shovels into small piles which, in turn, are spread with LUTES or RAKES. In the spreading process, all material should be thoroughly loosened and evenly distributed. Any part of the mix that has formed into lumps and does not break down easily should be discarded. After the material has been placed, it is then rolled. In areas difficult to reach with a roller, hand tampers are used.



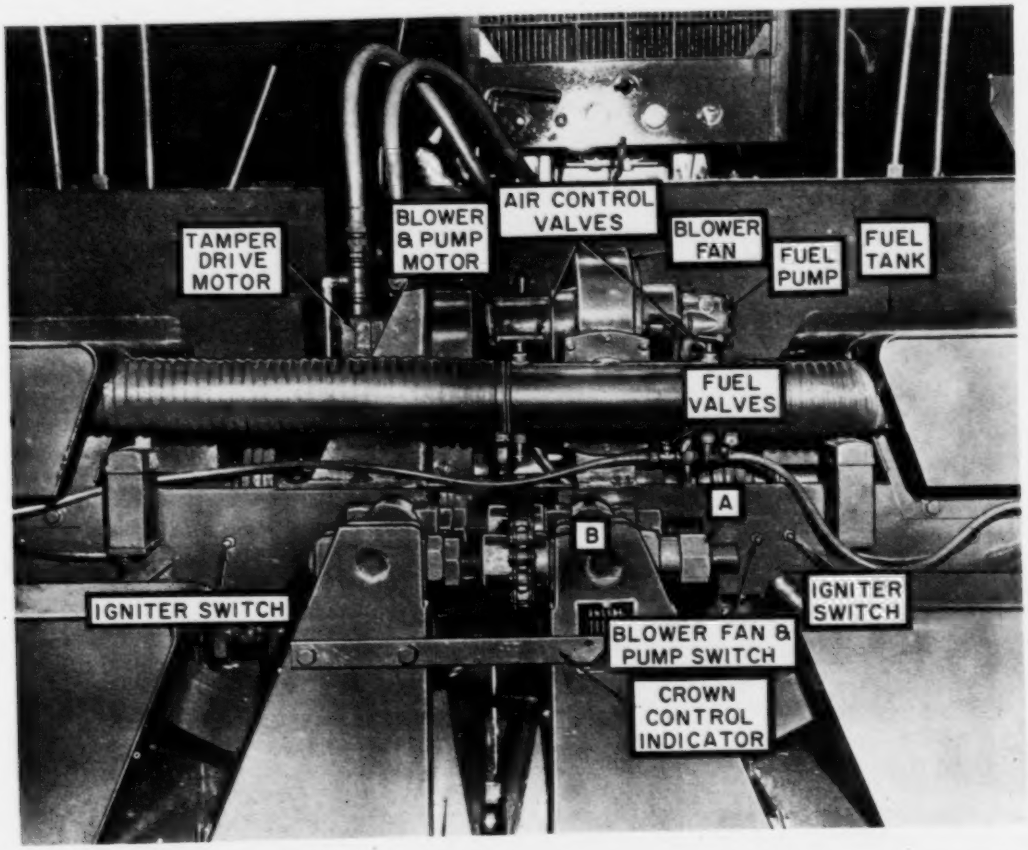
115.171

Figure 16-10.—Cross section of asphalt finisher tamper and screed.

COMPACTION EQUIPMENT

The following discussion on compaction equipment is limited to that used in bituminous operations. Remember that the initial use of any compaction method should be on a trial-and-error basis.

Rollers used for compaction and final rolling of hot asphalt mix are the 10-ton three-wheel, two- and three-axle tandem, and multiple-wheel pneumatic rollers. Navy two-axle tandems usually weigh from 5 to 8 tons, and three-axle tandems



115.401X

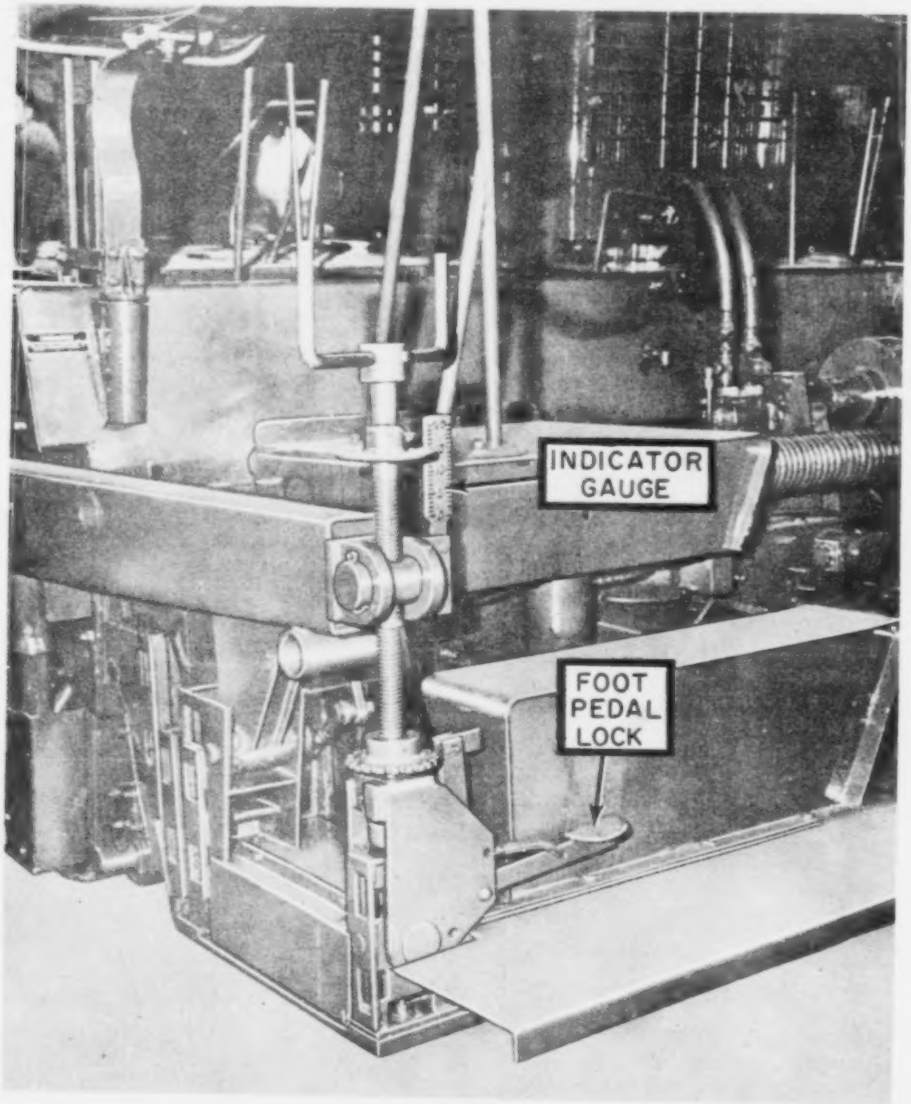
Figure 16-11. — Screed heater.

from 9 to 14 tons. Pneumatic tired rollers usually weigh 9 tons, fully ballasted.

Most compaction required in asphalt construction is achieved by the tamper on the finisher. Additional compaction and final surface texture are achieved by applying the rollers in the proper sequence. The hot mix should be at its optimum temperature for rolling when the rollers start to operate on the mat being laid. This optimum temperature will range between 225° to 250°F.

Breakdown rolling is done by the 10-ton three-wheel roller, secondary rolling by the two-axle tandem roller, and finish rolling by the penumatic-tired roller. With this combination of rollers, specified density should be obtained. If the required density is not obtained during construction, subsequent traffic will further consolidate the asphalt surface and cause ruts.

Rolling of the longitudinal joint should be done immediately behind the finisher. The initial, or breakdown, pass with the roller should be made as soon as it is possible to roll the mixture without cracking the mat or having the mix pick up on the roller wheels. The second rolling should follow the breakdown rolling as closely as possible. The finish rolling should be done while the material is still workable enough for removal of roller marks. Generally speaking, longitudinal joint rolling should start directly behind the spreader; breakdown less than 200 feet behind the spreader; second rolling 200 feet or more behind the breakdown rolling; and



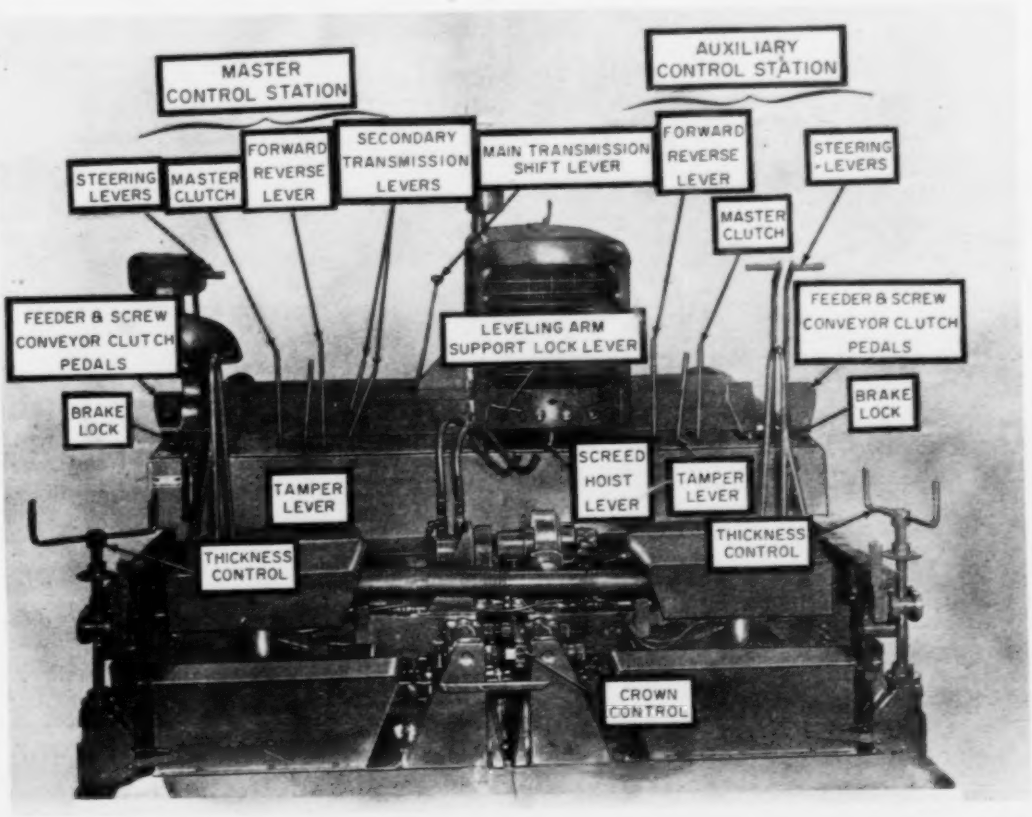
115.402X

Figure 16-12. — Thickness control.

finish rolling as soon as possible behind the second rolling.

During rolling, the roller wheels should be kept moist, using only enough water to avoid picking up material. Rollers should move at a slow but uniform speed, with the drive rolls nearest the finisher. With the drive rolls moving toward the finisher, the material will have less tendency to be displaced, as shown in figure 16-14.

The line of rolling should not be suddenly changed or the direction of rolling suddenly



115.403X

Figure 16-13.—Operating controls, Barber Greene model SA-35 finisher.

reversed, thereby displacing the mix. Any pronounced change in direction of the roller should be made on stable material. If the rolling causes displacement of the material, the affected areas should be loosened at once with rakes and restored to the original grade with loose material before being rerolled. Heavy equipment or rollers should not be permitted to stand on the finished surface until it has properly cooled or set. Rollers allowed to stand on a hot mat will sink in, thus causing depressions in the new mat.

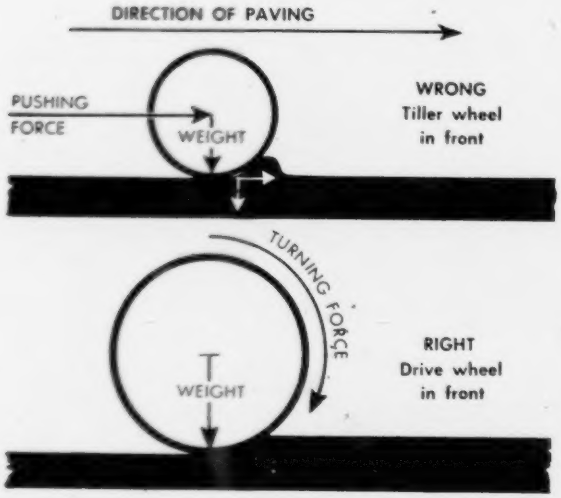
When paving with a single finisher, the first lane placed should be rolled in the following order:

(1) Transverse joints.
(2) Outside edge.
(3) Breakdown rolling, beginning on the low side and working toward the high side.
(4) Second rolling, same procedure as (3).
(5) Finish rolling.

When paving with two finishers working in echelon, or abutting a previously placed lane, the mix should be rolled in the following order:

(1) Transverse joints.
(2) Longitudinal joints.
(3) Outside edge.
(4) Breakdown rolling.
(5) Second rolling.
(6) Finish rolling.

When paving in echelon, 6 to 8 inches of the edge which the second paver is following should



115.404
Figure 16-14.—Rolling—direction is important.

be left unrolled. Then the second strip can be laid the same depth as the unrolled part of the first strip, and the roller can then compact the joint while the material is hot.

MAINTENANCE OF BITUMINOUS PAVEMENT

Maintenance and repair of roads and airfields are particularly important because of the constant and heavy mobility in modern warfare. Damage caused by the weight of heavy loads, by the abrasive action of military traffic, and by combat conditions must be repaired as quickly as possible. Repairs must often be made under difficulties, such as shortages of manpower, materials, and equipment; a lack of time; and the possibility of continuing or imminent attack.

Priority of maintenance and repair depends upon tactical requirements, traffic volume, and hazards that will result from complete failure of the paved area. A single pothole in a heavily used road, which is otherwise in excellent condition, should take priority over a pothole in an infrequently used road.

CAUSES OF SURFACE FAILURE

The principal causes of surface failure are subgrade or base failure, disintegration of the surface, instability, or combat failure.

As you learned in chapter 8, an asphaltic concrete pavement is directly dependent upon its base for its load-carrying capacity. WHENEVER THE SUBGRADE OR BASE COURSE FAILS, THAT PART OF THE WEARING SURFACE IMMEDIATELY ABOVE THE WEAKENED AREA WILL ALSO FAIL. Factors which may cause a base to fail include inadequate drainage, frost action, poor compaction, improper materials used for the subgrade or base, and overloading by transporting of exceptionally heavy equipment and materials.

The disintegration, or decomposition, of a wearing surface may be the result of hardening of the bituminous film. This hardening process, usually referred to as oxidation, starts at the time the bitumen is applied and continues during the life of the wearing surface. Continuous exposure to the weather slowly hardens the bitumen, which loses its resiliency and becomes brittle. Hardening may be caused by poorly designed mix, incorrect proportioning of the aggregate and bitumen, or inadequate mixing.

Water may be responsible for surface failure by causing the asphalt film to separate from the surface of the aggregate. If the aggregate absorbs too much water, the aggregate and bitumen may separate.

An unstable wearing surface is likely to deform under the impact of traffic. Causes of instability are as follows:

1. Too much bitumen.
2. Smooth aggregate.
3. Bitumen that is too soft.
4. Low density resulting from insufficient compaction.
5. Unsuitable mix design or gradation of the aggregates, and unsatisfactory placement.
6. Uncured prime.
7. Overpriming or excessive tack coat.
8. Dirt between the surface and base course.

Combat failure of a bituminous surface may be caused by bombing, shelling, or other enemy action. Nuclear airburst may harden or disintegrate a bituminous wearing surface. Continuous use of bituminous paved airfields by jet aircraft is likely to burn or scorch the surface, causing a pavement failure.

Other causes of surface failure are the use of unsuitable or insufficient bitumen, inadequate mixing, or a combination of these factors. The bitumen may also strip from dirty aggregate or be cut away by a petroleum distillate.

TYPES OF SURFACE FAILURE

Potholes are the most frequent type of failure found in bituminous wearing surfaces. Potholes may be caused by defective drainage, front action in the base, settlement of the base, or heavy traffic. A small pothole may be repaired with a hot or cold premix patch or a penetration patch. If a large area has many potholes, the entire area must be entirely reworked or replaced, depending upon the type of bituminous material used in the original pavement.

When the bond breaks down between the aggregate and bitumen a condition called raveling occurs. Raveling is disintegration of the surface, with damage starting at the top. This condition is frequently caused by a bitumen that becomes brittle and can no longer bind the aggregate together. A scorched bitumen or any of the factors that cause disintegration may produce reveling. Reveling is repaired by applying a skin patch or a seal coat (described later), as well as a fog seal or slurry seal.

Surface cracking first appears as minute hairline cracks visible only under careful scrutiny. The cracks run lengthwise of the road and appear to be numerous toward the edges of the traveled area. Surface water may seep through the cracks to the base and cause serious base failure and the formation of potholes. Cracks are cleaned with compressed air. Cracks wider than 1/8 inch are filled with lean sand-asphalt mix. The sand-asphalt mix is broomed into the cracks until they are full, then tamped with a spading tool. The filled cracks are sealed with asphalt and covered with sand. When surface cracks and checks are so extensive that water seeps through the cracks into the base course and endangers the pavement, a sand seal is applied. The pavement should be cleaned thoroughly and not more than 1/4 gallon per square yard of bituminous material applied. An even coating of clean, dry sand should be applied directly on the bitumen and rolled until the sand is well set. The area should not be opened to traffic until the bituminous seal has set and will not pick up under traffic.

Rutting and shoving of the wearing surface may be caused by instability. Defects caused by too much cutback in the bitumen may be corrected in road-mix pavement by blading the material from one side of the strip to the other until the volatile substances evaporate. For excess bitumen in the mix, sufficient new aggregate is added and mixing is continued until the bitumen is evenly distributed. The mix is then reshaped and rerolled, and a seal coat may be applied. In hot-mix pavements, excess bitumen requires removal and replacement of the affected area. Weakness of the base must be corrected by reworking the pavement.

Corrugation of a bituminous surface treatment frequently occurs when the bond has been broken between the surface and the underlying course. To repair this defect, the surface should be removed, the base reconditioned and primed, and a new surface treatment applied. Corrugation of a bituminous wearing surface may also be caused by any of the conditions discussed in the preceding paragraph and corrected in the same manner.

Bituminous materials that have been burned or overheated in processing of the mix become brittle and lifeless. The full depth of the pavement course constructed from such materials must be removed and replaced.

Bituminous surfaces frequently bleed, or exude bitumen, in hot weather. Bleeding causes a slippery condition that is hazardous to traffic and may possibly cause the surface to become rutted and grooved. This condition should be remedied as quickly as possible. Bleeding can be caused by too much bitumen being applied during prime coating or tack coating or by inadequate curing; in such cases the wearing surface must be replaced or reworked. As an expedient method for light bleeding, a light, uniform coat of fine aggregate or coarse sand should be applied. Fine sand is unsatisfactory. The pavement should be rolled, if possible, or the traffic permitted to compact the aggregate or sand. A light drag should be used to keep the aggregate or sand spread uniformly, and additional applications made as required. For heavy bleeding, a large aggregate is used.

When settlement is caused by failure of pipes, culverts, or supporting walls, repairs to these structures must be made before surfacing. Minor settlements and depressions frequently are repaired by surface treatments. The edge of a depression should be marked with chalk or paint.

The surface of the pavement within the marking should be cleaned thoroughly and a tack coat applied of not more than 0.1 gallon per square yard. Materials should be used similar in character and texture to those in the adjacent pavement. The patching material should be placed, raked, and rolled. Larger settled areas are repaired with one or more applications of bituminous material on top of the existing surface, or by removing the surface course and bringing the base up to proper grade. Under suitable weather conditions, many types of bituminous surfaces may be bladed to one side of the affected area and then relaid after the base is readjusted.

TYPES OF PATCHES

The types of patches used for repair of bituminous wearing surfaces are: premixed patch, penetration patch, skin patch, and seal coat (surface treatment). If damage is extensive, the entire paving system should be reworked or replaced.

Both hot and cold mixes are used for premixed bituminous patches. Small quantities of hot mix or cold mix often may be obtained locally or the mix may be prepared on the job. Hot mixes prepared at a central plant are generally used for extensive repair. Hot mix can be used with less delay from inclement weather than cold mix, and hot-mix patches can be opened to traffic in a shorter time. New cold-mix patches displace easily under traffic before the volatile substances have evaporated. Hot-mix patches have a longer life than cold-mix patches and less tendency to ravel at the edges. Hot-mix patching material is prepared in accordance with instructions set down at the central plant. In most cold-mixes, dry aggregate is required for a satisfactory mix. The amount of bitumen to be used is just as important in patching mixes as it is in mixes for construction of new pavements.

A penetration patch is made with macadam aggregate (which should be broken strone or slag, with a maximum size of 2 to 3 inches, depending on the depth of the hole) and a suitable bitumen. (See table 6-1.) Layers of suitable base material should be placed, compacted, lightly tacked, and a coarse layer of aggregate tamped into the hole which has been prepared in accordance with the procedures shown in figure 16-15. The bitumen used may be asphalt cement or a rapid-curing emulsion. Rate of application is usually 1 gallon per square yard for the top inch, and 1/2 gallon per square yard for each additional inch of depth. Ensure that the final surface patched is slightly high to allow for compaction by traffic. Excess bituminous material should be avoided in a penetration patch. If time and personnel availability permit, a firm compaction of subbase material can be accomplished by repeatedly filling the pothole with materials on hand until the traffic has fully compacted the subbase. When traffic has sufficiently compacted the subbase, repair can proceed as illustrated in figure 16-15.

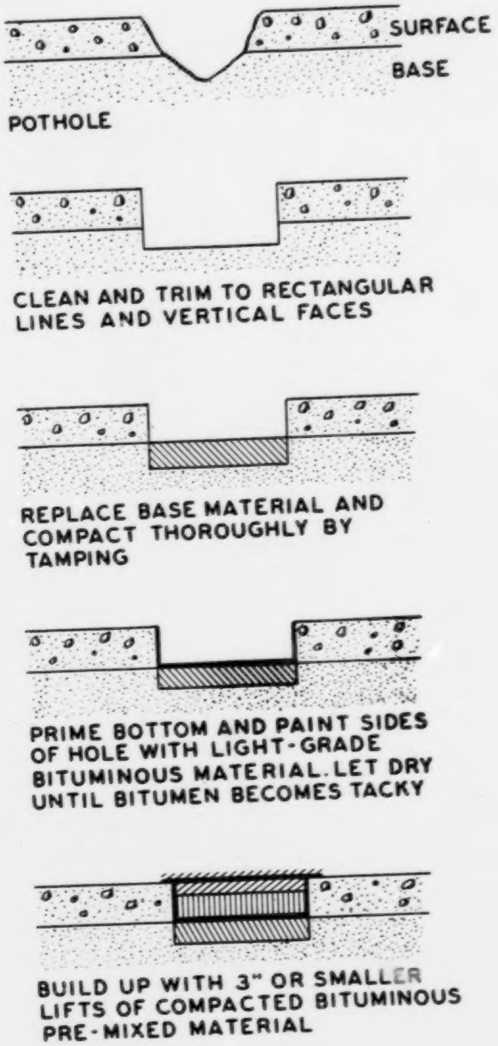
A skin patch is a single surface treatment used to correct cracking and raveling in small areas of the wearing surface. Skin patches seal the defective areas and recondition the wearing surface. In applying a skin patch, the damaged area is swept clean and a coat of asphalt cutback applied. The bituminous coat is then covered with fine aggregate and lightly rolled or tamped to seal the aggregate. The aggregate generally used is about 1/4-inch stone or clean, coarse sand. In general, approximately 1 gallon of bitumen is used for 100 pounds of aggregate, regardless of the size of the aggregate.

A seal coat is a single surface treatment used to seal large cracked or raveled areas. Basically, a seal coat is a sprayed application of bitumen covered with a thin layer of aggregate. The amount of bitumen depends upon the type of aggregate; usually about 1 gallon of bitumen is needed for every 100 pounds of aggregate. Double surface treatments may be used if necessary.

ASPHALT KETTLE

The asphalt kettle shown in figure 16-16 is equipped for hand-spraying bituminous materials for dressing stretches or road or runway shoulders, filling surface cracks, and spray coating areas for sheet asphalt repairs, surface treatment, or seal coating.

The trailer-mounted tank consists of an outer shell with a 165-gallon capacity storage and melting tank mounted inside. A removable fuel burner, mounted inside the kettle outer shell, provides heat to the melting tank through a baffle. A flue stack, located on the forward end of the melting tank over the top of the baffle and burner assembly, provides an escape for exhaust gases. A thermometer, inserted through


SURFACE
BASE
POTHOLE
CLEAN AND TRIM TO RECTANGULAR LINES AND VERTICAL FACES
REPLACE BASE MATERIAL AND COMPACT THOROUGHLY BY TAMPING
PRIME BOTTOM AND PAINT SIDES OF HOLE WITH LIGHT-GRADE BITUMINOUS MATERIAL. LET DRY UNTIL BITUMEN BECOMES TACKY
BUILD UP WITH 3" OR SMALLER LIFTS OF COMPACTED BITUMINOUS PRE-MIXED MATERIAL

143.69

Figure 16-15.—Steps in patching a pothole or burned area.

an insulated pipe into the interior of the melting tank, indicates the temperature reading of the heating bituminous material. If the bituminous material is overheated, a fire or explosion can result.

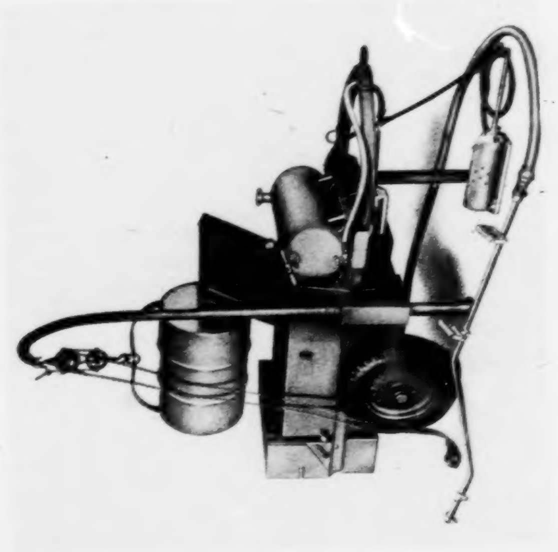


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Figure 16-16.—Asphalt kettle.

A two-cylinder gasoline engine provides power for the bitumen pumping system. By shifting the clutch shifter lever, the engine is engaged to the pump assembly which provides the pressure for all pumping operations. A flexible, metal spray hose, which connects the pump to the hand-held spray bar assembly, is used to convey bitumen to the surface being repaired.

MAINTENANCE OF EQUIPMENT

As an Equipment Operator, it is your responsibility to coordinate the proper operation, care, use, adjusting, cleaning, preservation, and lubrication of paving and support equipment. This includes daily inspections and adjustments required for good operation. Malfunctions in equipment, which go beyond those operating adjustments performed by the EO, should be referred to the field mechanic for corrective action. This does not release you from working with the field mechanic unless directed otherwise.

You, the EO, serve a very important function in preventive maintenance. You are required to perform specific daily and scheduled maintenance services on your equipment. Proper performance of these services does much to prolong the life of the equipment, to avoid major repairs, and to assure that your equipment will perform its mission consistently and dependably. Acceptable maintenance standards applicable to any particular piece of equipment you operate have been established by the manufacturer of that equipment and should be followed. Instructions and directives put out by your unit must also be followed. They may include periodic inspections, testing, and observation of your operational techniques. You are responsible for certain forms, records, and reports in the performance of your maintenance services and daily operations. Get to know the applicable maintenance procedures and carry out the directives accordingly.

PAVING SAFETY

This section deals with safety precautions applicable to paving operations. We are particularly interested in such topics as the heating of asphalt materials, traffic control, plant safety, equipment operation, cleaning bituminous handtools, and safe practices applicable to the personal safety of the operator and other persons who may be working as crewmembers.

Construction with bituminous materials involves several hazards. One of the most serious dangers is associated with the heating required to convert the solid or semi-solid materials to a degree of fluidity which will permit their application and/or mixing. As a safety measure, make sure fire extinguishing equipment (foam-type) is present at all times.

When readying the distributor and/or asphalt kettle, be sure they are in a level position before heating and are located a safe distance from buildings and other flammable materials. Keep covers closed during the heating period to prevent escape of flammable vapors, and avoid exposure to fumes from hot bituminous material — stay on the windward side.

When heating bituminous materials for spraying purposes, check the temperature suggested in table 16-2 for the type and grade being used. Remember that most of the flash points are exceeded before the materials reach spraying or working temperature; therefore, additional caution must be exercised to prevent the exposure of rising fumes to an open flame. A dense yellow cloud or vapor rising from the distributor or kettle is an indication that the material is being overheated to the extent that a small spark is sufficient to ignite the vapors.

Table 16-2. — Suggested Temperatures for Uses of Asphalt

Type and Grade of Asphalt	Pugmill Mixing Temperature of Aggregates*	Distributor Spraying Temperature
Asphalt Cements		
(For Open-Graded Mixes, Types I & II)**		
40-50	225-310°F	
60-70	225-305°F	
85-100	225-300°F	
120-150	225-300°F	
200-300	225-300°F	
(For Dense-Graded Mixes, Types III-VIII)**		
40-50	275-350°F	
60-70	265-330°F	
85-100	255-325°F	
120-150	245-325°F	
200-300	225-300°F	
(For Distributor Spray Applications)		
40-50***		300-410°F
60-70***		295-405°F
85-100		290-400°F
120-150		285-395°F
200-300		275-385°F
Liquid Asphalts		
RC, MC, and SC Grades		
30	60-105°F	
70	95-140°F	
250	135-175°F	
800	165-205°F	
3000	200-240°F	
Asphalt Emulsions		
RS-1	****	75-130°F
RS-2	****	110-160°F
MS-2	50-140°F	100-160°F
SS-1	50-140°F	75-130°F
SS-1h	50-140°F	75-130°F
RS-2K	****	75-130°F
RS-3K	****	110-160°F
CM-K	50-140°F	100-160°F
SM-K	50-140°F	100-160°F
SS-K	50-140°F	75-130°F
SS-Kh	50-140°F	75-130°F

*The temperature of the aggregates and asphalt immediately before mixing should be approximately that of the completed batch.

**Mix Type III is intermediate between dense- and open-graded mixes. As the gradation of the mix changes from dense-graded to open-graded the mixing temperature should be lowered accordingly.

***Not normally used for spray applications in pavement construction.

****Not used for mixing.

115.407

Always extinguish burners before spraying bituminous material. When spraying, stand at least 25 feet clear of the spray bar on the bituminous distributor; spray bars have been known to blow open or rip with sudden pressure of heated materials. Remember that bituminous material must be heated to a high temperature, and any of this material coming in contact with the skin will leave a serious burn.

When handling asphalt being processed, wear proper protective apparel. Wear loose, heavy clothing — in good condition. Clothing should be closed at the neck, sleeves rolled down over the top of gloves, and trousers (without cuffs) extending well down over the top of shoes (safety type). Goggles should be worn to prevent eye burn from bubbling or splashing asphalt. In addition, wear a safety hat.

Frequently, bituminous operations will be planned for roads that must carry traffic while work is in progress. Slow signs or other warning devices should be conspicuously placed at both 100 yards and 20 yards from each entrance of the project. Flagmen, dressed in safety vests or some other attire, should aid in traffic control.

It will be necessary for most airfields to remain operational (if possible) during bituminous operations. The construction schedule, equipment routing, and maximum height of equipment should be discussed with the airfield safety officer. Liaison with air traffic control must be established if trucks and other equipment are to cross runways that are in use.

Guards, safety appliances, and similar devices are placed on moving parts in both asphalt and concrete plants for the protection of personnel. They must not be removed or made ineffective except for the purpose of making immediate repairs, lubrication, or adjustments, and then, only after the power has been shut off. All guards and devices must be replaced immediately after completion of repairs and adjustments by maintenance personnel.

There should be a platform near the truck loading or unloading area from which the mix or materials may be observed. There should also be a horn or buzzer for the plant operator to signal a truckdriver to move his vehicle. In addition, a "panic button," or switch, should be located a short distance from the plant. This panic button, or switch, can be used to stop all plant operations in event of an emergency. The area around mixing plants should be kept clean and clear of any waste material.

Machinery and mechanized equipment must be operated only by qualified and authorized personnel. It must not be operated in a manner that will endanger personnel or property, and the safe operating speeds or loads be exceeded. Equipment requiring an operator must not be permitted to run unattended. Mounting or dismounting equipment while in motion, or riding on equipment by unauthorized personnel, is prohibited. All equipment using fuel must be shut down, with ignition off, prior to and during refueling operations.

When operating paving equipment, frequent inspections of running mechanisms and attachments are the operator's responsibility. He is also responsible for inspecting such items as the power train, power plant, transmission, tracks, controls, skip guards, cables, sheaves, loading or unloading warning devices, and receiving hoppers.

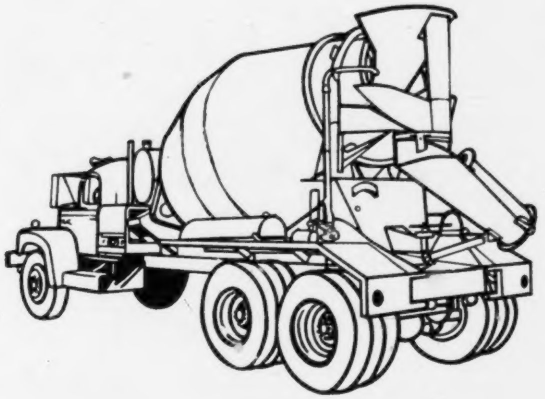
In applying paving materials, crewmembers often become so occupied with their particular job that they are unaware of equipment operating near them. For this reason, at least one crewmember should be designated as safety inspector to ensure that reasonable precautions are observed within the assigned working areas. In addition, the safety inspector periodically holds short (approximately 5 to 15 minutes) safety meetings, called Stand-up Safety meetings, during which he briefs his crew on hazards and precautions relating to current work.

All handtools used for paving purposes must be kept in good repair and used only for the purpose for which designed. When using handtools such as rakes, shovels, lutes, and hand tampers on asphalt paving jobs, these tools should be heated before use and cleaned immediately after use. It is common practice to clean these handtools by burning off the bitumen collected during paving operations. Crewmembers should exercise caution and be forewarned that flames are not always visible. One man should stand by with a fire extinguisher capable of controlling a petroleum fire.

All personnel should be instructed to report promptly all personal injuries and property damage regardless of how minor. Reports should be prepared in accordance with instructions set forth in base of command publications.

CONCRETE TRANSIT MIXERS

The concrete transit mixer is a production tool designed to deliver and mix concrete. You, as an EO, are responsible for the safe and timely delivery of your load. You are also responsible



115.502
Figure 16-17.—Concrete transit mixer.

for manufacturing concrete and safeguarding the quality of the concrete en route to and at the jobsite until the concrete has been discharged.

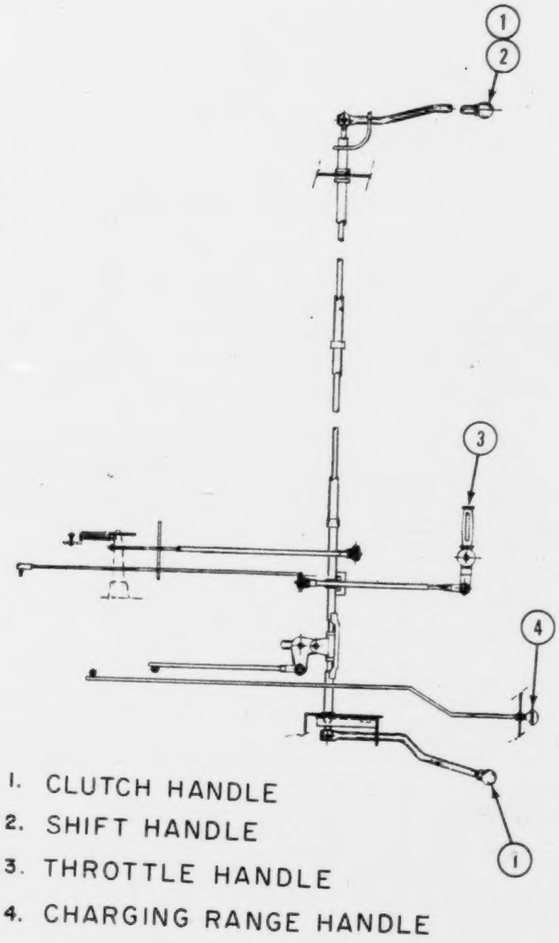
OPERATING CONCRETE TRANSIT MIXERS

The information given below is on the Challenge series 01 concrete transit mixer (fig. 16-17), and applies ONLY to that machine. This information will give you an idea of how one of the several types of transit mixers used by the SEABEES is operated.

Before operating the transit mixer, you should first become familiar with its controls (fig. 16-18). The purpose of the various controls is explained below; the numbers in parentheses correspond to those used in figure 16-18 to indicate the location and purpose of the controls.

The CLUTCH LEVER (1) is known as the "Uni-Lever" in that the actions of the clutch, throttle, and drum rotation are incorporated in the one lever. The "Uni-Lever" located at the rear of the mixer has three functions. In addition to serving as clutch and throttle, the lever also controls the direction of drum rotation. The shifting of drum rotation may be accomplished ONLY at the rear station (2).

The HAND THROTTLE (3) is mounted on the auxiliary frame runner at the left front control station. The hand throttle is used (1) to regulate engine speed while charging the mixer, (2) to set the engine speed for transit, and (3) for any other applications which may require a constant engine speed.



115.503
Figure 16-18.—Transit mixer controls.

The CHARGING RANGE CONTROL LEVER (4) is located on the UPPER left corner of the instrument panel at the front control station. This lever is mechanically connected to the two-speed transmission; this gives the operator an additional speed range for charging. To select the desired speed range, disengage the clutch, select the appropriate speed range, and re-engage the clutch.

Before you can fulfill your responsibility as a transit truck mixer operator, some basic knowledge of the nature of concrete and of its proper mixing procedures must be known.

The basic ingredients of concrete are aggregates (such as gravel and crushed stone), sand, cement, and water. Small quantities of admixtures may also be added to achieve certain characteristics such as air entrainment or better workability. The aggregates normally comprise approximately 65 to 80 percent of the total volume of ingredients, while the cement and water together comprise about 20 to 35 percent.

Various kinds of concrete are produced to meet specific needs in construction work. Concrete of the desired quality is obtained by varying the sizes, types, and quantities of aggregates, as well as the type and amount of cement, the amount of water, and the types and amounts of admixtures. The kinds and quantities of each material are spelled out in a "mix design" for specific jobs and are standardized for many jobs that are similar in nature.

Types of Mixer Operation

The transit truck mixer is used with any type of ready mix concrete mixing and hauling procedure, including central mixing, shrink mixing, transit mixing and jobsite mixing. In hauling central mixed concrete the truck mixer serves as an agitator keeping the concrete well mixed en route to the job by turning the drum at agitating speed. In shrink mix operations the materials are combined and the mixing process is begun at the plant. Then the concrete is loaded into the mixer, and the mixing is completed in the truck mixer. In transit mixing the materials are loaded into the truck mixer at the plant, and all of the mixing is accomplished by the truck mixer en route to the job. Some project plans specify that the concrete must be mixed at the jobsite. On this type of operation, all the materials except the water are loaded into the truck mixer drum at the plant. The mixer, equipped with one of the optional large water tanks and water measuring devices, adds the mixing water at the jobsite and performs the entire mixing operation there.

Ideal Mixing Conditions

Ideal conditions for mixing concrete include simultaneous loading of cement, sand, water and aggregate (to obtain initial intermingling of materials), followed by 70 to 100 turns of the mixer drum at normal mixing speeds of approximately 7 to 11 rpm. Of these three critical steps: proper charging, adequate drum speed, and the correct number of drum revolutions during the mixing cycle, the charging operation (described later in this chapter) is most important.

At variations from simultaneous loading will make mixing more difficult and will require additional drum revolutions at mixing speed.

Avoid Overmixing

Overmixing damages the quality of the concrete, tends to grind the aggregates into smaller pieces, increases the temperature of the mixture, lowers the slump, decreases air entrainment, and decreases the strength of the concrete. Overmixing also puts NEEDLES WEAR on the drum and blades.

In selecting the best mixing speed for each trip, the operator of a transit mixer should estimate the travel time (in minutes) to the job and divide this into the minimum desired number of revolutions at mixing speed — 70. The result will be the best drum speed. For instance, if the haul is 10 minutes, 70 divided by 10 equals 7. With this drum speed, the load will arrive on the job with exactly 70 turns at mixing speed — no overmixing and no unnecessary equipment wear. If the load cannot be discharged immediately, the driver should turn it at 2 rpm (minimum agitating speed) until he can discharge it. Since he arrived on the job with no more than the minimum number of mixing turns completed, he is able to wait longer (if necessary) without accumulating more than the maximum permissible number of total turns (250).

To simplify the selection of proper mixing speeds and to allow a margin for error that will cover variations in driving conditions, the operator may choose to use mixing speeds between 5 and 10 rpm, rather than 4 to 12 rpm. Working within the 5 to 10 rpm range, dividing 70 by estimated travel time will produce the desired drum speed for any trip from 7 to 14 minutes in length. For trips shorter than 7 minutes, the driver will continue to turn his drum at 10 rpm for the full 7 minutes, even though a portion of that time is at the jobsite. For trips longer than 14 minutes in length, the driver will maintain a drum speed of 5 rpm for 14 minutes (producing a total of 70 turns at mixing speed), then change to 2 rpm (agitating speed) for the balance of the trip, and for waiting time on the job, if any.

Batching and Charging Procedures

In order to produce quality concrete, you should strive to obtain uniform ribbon loading of all materials throughout the entire charging operation. Ribbon loading is best because it allows intermingling of the materials as they enter the drum, providing a head start on the mixing operations.

For transit mixing and jobsite mixing, the mixer should be charged with the truck engine running at near full throttle and the mixer control lever in the charge position. This will produce a drum speed of about 16 rpm. For central mix and shrink mix operations a little less throttle, which will produce a charge speed of 12 to 14 rpm, is generally adequate. As soon as the load is charged, the hand throttle or remote throttle should be closed and the drum speed reduced to the desired mixing speed.

Discharging

The unloading operation can be controlled from the control station at the rear or from the cab, whichever seems to best suit the job conditions. In either case, the throttle should be set partially open and the discharge speed controlled with the mixer control lever. Returning the control lever to its neutral position will automatically stop the drum. If the interruption is of any significant length, the control lever should be moved to agitate speed. The load can also be discharged with the truck in motion if required, such as in curb and gutter placement. With the mixer engine throttle positioned for slow speed, the "Uni-Lever" can be moved to whatever position will produce the needed discharge rate to fill the forms.

When discharging concrete from a mixer equipped with a sealing door, the door should be opened wide to prevent segregation or straining of materials. When discharging is intermittent as in wheelbarrows, buggies, buckets, etc., the rate should be controlled by manipulation of the mixer control lever—not the engine throttle.

Mixer Cleaning

At the jobsite: Immediately after discharging all concrete to the required project, you should wash off the excess concrete in the mixer drum and blades, the discharge opening, and the discharge chutes before it has a chance to harden. Spraying 15 to 25 gallons of water into the drum while it is revolving will clean the inside of the drum as well as remove all grout which may have collected in the water nozzle during discharge. This may be carried back to the plant and subtracted from the next load. A washdown hose is provided to clean areas accessible from the outside. A clean mixer produces a more satisfactory mixing and discharging of concrete.

CAUTION: Wash the mixer with water only for the first 30 days of operation. Any stains occurring within the first 30 days can be washed off with a mild detergent. Thoroughl rinse with clear water. Avoi washing in the sun. The use of acids or abrasives may cause severe loss of gloss.

At the plant: A minimum of 150 to 250 gallons of water, depending on the size of the mixer, should be used to thoroughly clean the drum immediately at the end of each day's run. With the flush water in the drum, rotate the drum in the mixing direction for a few minutes, then discharge the flush water at maximum drum rpm. Complete cleaning the outside of the mixer, particularly around the discharge end.

By using a mixture of half paraffin oil and half diesel oil, the truck and concrete mixer can be sprayed in a few minutes; this prevents or retards the concrete from adhering to the structural members. After the entire unit has been thoroughly sprayed, it can be washed down with an ordinary garden hose at the prescribed line pressure.

If the above procedure is followed daily, it will result in increased efficiency, as well as reduce maintenance costs, of the equipment.

Hydraulic Chute Hoist

The manual hydraulic chute hoist is simple to operate and requires very little maintenance.

This hoist consists of an oil reservoir and a hydraulic pump with a flow control valve and a hydraulic cylinder secured to the chute. By hand pumping and manipulation of the flow control valve, the operator may raise, hold, or lower the chute to any desired position.

Hints for trouble free operation:

1. Check oil level in reservoir.
2. Keep breather on top of reservoir clean. If this breather becomes clogged, a vacum will result.
3. Use clean oil when adding oil.

The friction lock chute brake is designed to control the swing of the chute through a 180° range. The operator may lock it at any position simply by tightening down on the handle, or it may be desirable to apply just enough drag so that a slight tug will move the chute. This arrangement may save damage to the chute in case it is forced against a solid object.

SECURING

When securing a concrete transit mixer, position the concrete discharge chute so that it is parallel to the mixer drum. Wash down the unit as described in previous paragraphs, place mixer controls in neutral, and secure mixer engine. Drive the transit truck to the designated securing area and position in a safe manner. Secure the truck as described in chapter 5 of this manual for automotive vehicles.

OPERATOR'S CARE AND MAINTENANCE

Every operator is required to perform certain daily maintenance services on the concrete transit mixer he operates. This maintenance includes the required inspection service, lubrication, and adjustments required to maintain the concrete transit mixer in a safe and operable condition, prevent malfunctions, and avoid or delay major repairs.

In order to maintain efficient operation of the mixer, it is important that you clean the mixer thoroughly once a day, in addition to washing it down after discharging each load. Lubricate the mixer and the mixer engine daily, in accordance with the manufacturer's instructions. Service the engine air filter regularly, check the truck frame and mixer mounting bolts, and maintain correct drum chain adjustment.

Oils which are used in the hydraulic system perform the dual function of lubrication and transmission of power. Select and use only the type recommended by the manufacturer.

Special worm gear or compound steam cylinder oil is used in the worm gear drive. Do not use automotive or hypoid type "all purpose" oil. Do not add any compound. Check oil level daily, change oil after 2 weeks of operation and every 3 months thereafter. The oil capacity is given on the instruction plate attached to the mixer housing.

The frequency of oil change and oil filter element replacement for the mixer engine depends upon the operating conditions encountered. Under normal operating conditions, the oil and filter element should be changed after every 100 hours of operation.

Since engines used in mixers may vary, it is advisable that you comply with the recommended oil viscosity, general care, and maintenance procedures outlined in the manufacturer's operating manual.

The lubricant used on the mixer roller chain must be thin enough to enter a chain joint and must be applied frequently enough that a film of lubrication is constantly maintained inside the joints. A coating of hard grease will collect and hold abrasive particles, resulting in undue wear on both chains and sprockets. To prevent corrosion, reduce wear rate of chains, and lengthen sprocket life, use of SAE 30 engine oil is recommended by the manufacturer for mixer chain lubrication. Apply oil to the chain joints daily with an oil can or brush.

TRANSIT MIXER SAFETY

The increased use of transit mix trucks on construction projects imposes traffic problems which must be considered. Caution must be used during backing of the transit truck. Backing should be controlled by a signalman, positioned so that the operator can clearly observe the directions given.

Use extreme caution when traveling over uneven terrain on a construction site. The stability of the mixer is greatly reduced with the extra weight of the concrete in the mixer unit. In such cases, a slow speed is recommended.

Some additional safety precautions that must be observed are as follows:

1. Reduce speed before making a turn or applying the truck brakes.

2. Secure discharge chute properly, using the friction brake lock provided.

3. Check to make certain that other personnel are in the clear before starting the mixer charging or discharging.

4. Before making any adjustments, make certain that the mixer engine is not running; this is particularly important when the clutch or drum chain is to be adjusted.

5. Secure mixer engine before refueling.

CHAPTER 17

HANDLING AND HAULING EXPLOSIVES

As an Equipment Operator, you will frequently be working with explosives which will be utilized by the Naval Construction Force in blasting and quarrying operations. You must, therefore, study and get to know the regulations governing the handling and hauling of explosives.

This chapter will discuss briefly regulations which have been written especially for Navy drivers engaged in the transportation of ammunition, explosives, and other dangerous articles that they may have to transport intrastation or over public highways. Throughout the discussion, special attention is given to safety precautions applicable to handling and hauling such articles.

EXPLOSIVES

Explosives may be defined as any substance or mixture of substances that, on impact or by ignition, reacts in a violent manner. For our purposes here, explosives may be classified as follows:

Class A Explosives. Chemical compounds, mixtures, or devices (mass detonating, spark-initiated, or shock sensitive) with maximum shipping hazard. Examples are block powder, PETN (a granular powder), explosive warheads, nitroguanadine (dry), and dynamite.

Class B Explosives. Explosives which function by rapid combustion rather than detonation. Examples are rocket ammunition without projectile, special fireworks, and jet engine starter cartridges.

Class C Explosives. Devices which contain Class A or Class B explosives or both, but in restricted quantities, and certain type fireworks. Examples are electric squibs, explosive bolts, common fireworks, and small arms ammunition.

MOTOR VEHICLES

A motor vehicle is any vehicle, machine, tractor, trailer, semitrailer, or double trailer propelled or drawn by mechanical power and used on the highway in the transportation of property. Types of vehicles that you may use in the handling and hauling of explosives are as follows:

Double Trailer—applies to a full trailer attached to a semitrailer powered by a single tractor.

Full Trailer—means any motor vehicle, with or without motive power, designed to be drawn by another motor vehicle and constructed so that no part of its weight, except the towing device, rests upon the towing vehicle.

Semitrailer—means any motor vehicle, with, or without, motive power, designed to be drawn by another motor vehicle and constructed so that some part of its weight rests upon the towing vehicle.

Truck—means any self-propelled motor vehicle, except a truck-tractor, designed and used, or exclusively used whether or not so designed, for the transportation of property.

Truck-Tractor—means a self-propelled motor vehicle designed and used primarily for drawing other vehicles, and not so constructed as to carry a load other than a part of the weight of the vehicle and load so drawn.

WEIGHTS

The terms "gross weight," "net weight," and "tare weight," when used in reference to a loaded truck, have a special meaning, as indicated below.

GROSS WEIGHT means the weight of the truck, plus the weight of its load.

NET WEIGHT means the weight of the contents of the truck, exclusive of the truck.

TARE WEIGHT means the weight of the truck, exclusive of its load.

SPECIFICATIONS

The transporting of Class A, B, and C ammunition, explosives, or other dangerous articles on-station and over public highways is authorized in trucks, full trailer, semitrailers, and double trailers equipped with closed bodies, flatbeds, stake sides, and open tops. (See fig. 17-1.)

Fully Closed Vehicle

The exterior of fully closed vehicles should be constructed of fire-resistant or fireproof material. There should be no exposed ferrous metal on floors or interior walls. The doors must be tight-fitting, securely affixed to hinges, and equipped with suitable latches and operational locks.

Pickup Trucks and Flatbed, Stake Side or Open Top Vehicles

Material shipped in pickup trucks and flatbed, stake side, or open top vehicles normally will be covered with fire-resistant and waterproof tarpaulins, which are securely fastened to the vehicle in such manner as to fully protect the load from sparks, fire, and moisture. However, no tarpaulin is required when the material is packed in metal or wooden containers that have been tested in accordance with Navy Standards, and have been proved to be fire-resistant and waterproof. The use of flatbed equipment is authorized only when the lading is palletized or packed in large metal or wooden containers, and when the load will lie entirely within the horizontal outline of the flatbed without overhang or projection.

Safety Equipment

It will be your duty, as the driver of a truck carrying dangerous cargo, to inspect your truck for the following equipment:

1. Proper placards affixed to both sides, end, and front of the vehicle. (Further information on placards is given later in this chapter.)
2. Two fully charged fire extinguishers installed, except that when transporting Class C explosives or inert material, only one fire extinguisher is required. (Further information on fire extinguishers is given later in this chapter.)
3. Tools for changing spare tires.

Other necessary items of motor vehicle equipment and accessories which should be carried in the cab of the vehicle for off-station shipments are shown in figure 17-2. Only items m through p are required for on-station movements.

REQUIREMENTS FOR EXPLOSIVES DRIVERS

All Navy drivers of vehicles carrying ammunition, explosives, or other dangerous articles will be required to read and understand the regulations pertaining to their duties, which are described in your command publications and directives. The Safety Officer, or other authority designated by your Commanding Officer, will be responsible for the distribution of these publications and directives.

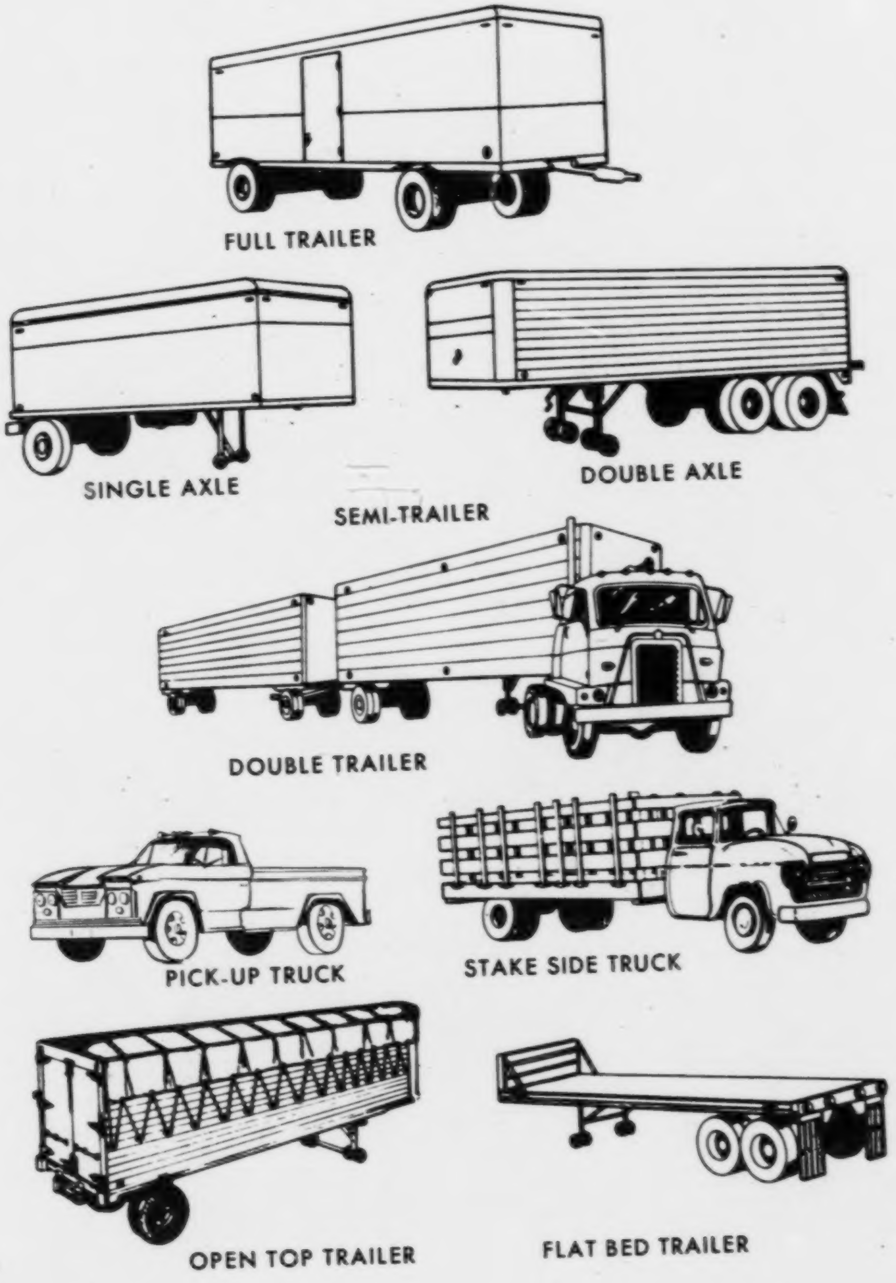
TRAINING COURSE

An Explosives Driver's training course should be carried on continuously at the local level. All drivers of trucks carrying dangerous cargo should receive special instruction and training in the following:

1. Driving truck-tractors with semitrailers and other vehicles of appropriate types.
2. Handling and transporting ammunition, explosives, and dangerous articles.
3. Firefighting.
4. Completing and filling required reports.

DRIVER'S PERMIT

A driver qualified to transport dangerous cargoes must hold a "U.S. Government Motor Vehicle Operator's Identification Card, "Standard Form 46, on which is noted "Explosives Driver." This permit must be renewed each year on the basis of the driver's safety record and his ability to meet physical requirements (explained later). A Navy driver must also hold a valid state operator's permit, not necessarily issued by the state in which your activity is located; however, for on-station use only, a state permit is not necessary.



115.408

Figure 17-1.—Representative motor vehicle types.

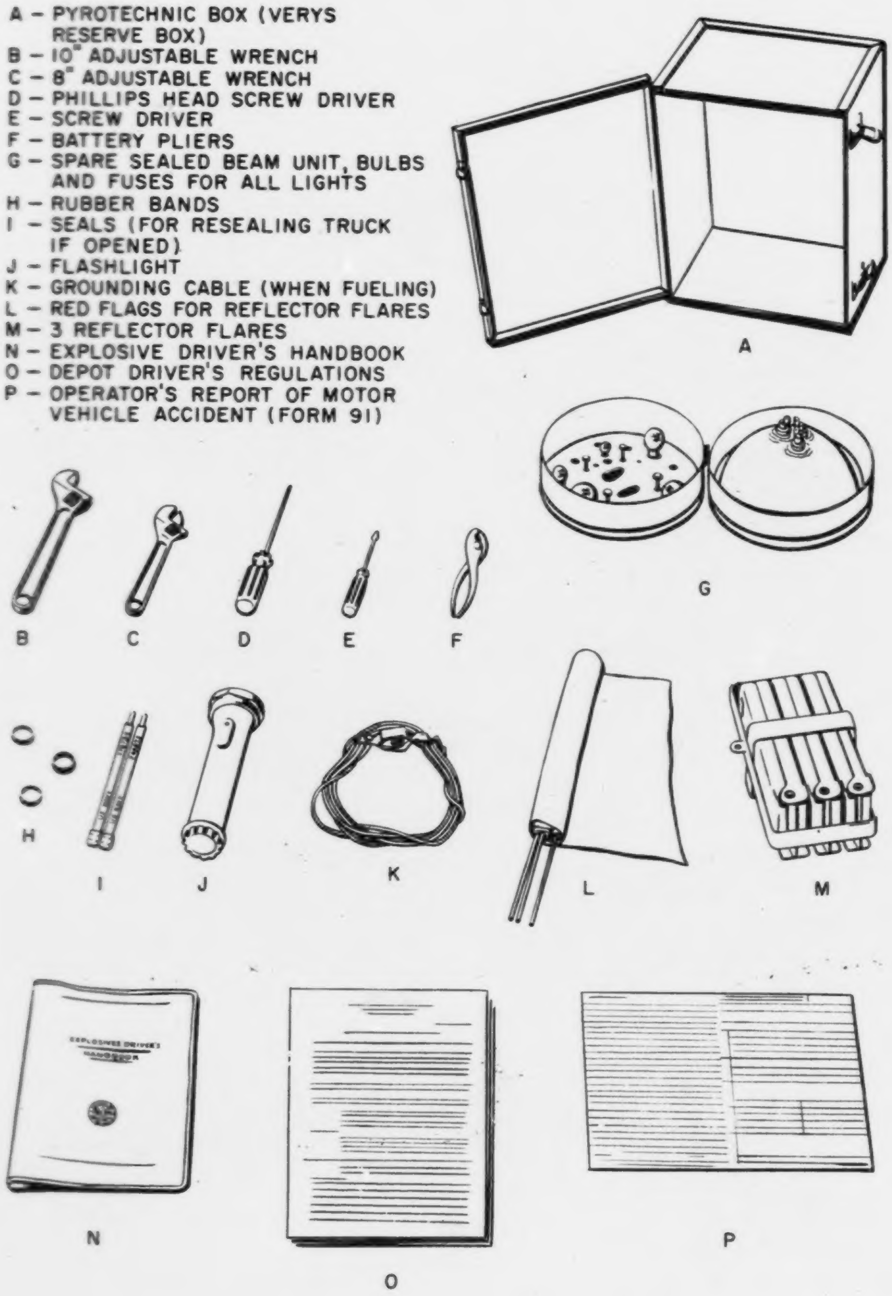

A – PYROTECHNIC BOX (VERYS RESERVE BOX)
B – 10" ADJUSTABLE WRENCH
C – 8" ADJUSTABLE WRENCH
D – PHILLIPS HEAD SCREW DRIVER
E – SCREW DRIVER
F – BATTERY PLIERS
G – SPARE SEALED BEAM UNIT, BULBS AND FUSES FOR ALL LIGHTS
H – RUBBER BANDS
I – SEALS (FOR RESEALING TRUCK IF OPENED)
J – FLASHLIGHT
K – GROUNDING CABLE (WHEN FUELING)
L – RED FLAGS FOR REFLECTOR FLARES
M – 3 REFLECTOR FLARES
N – EXPLOSIVE DRIVER'S HANDBOOK
O – DEPOT DRIVER'S REGULATIONS
P – OPERATOR'S REPORT OF MOTOR VEHICLE ACCIDENT (FORM 91)
A
G
B
C
D
E
F
H
I
J
K
L
M
N
O
P

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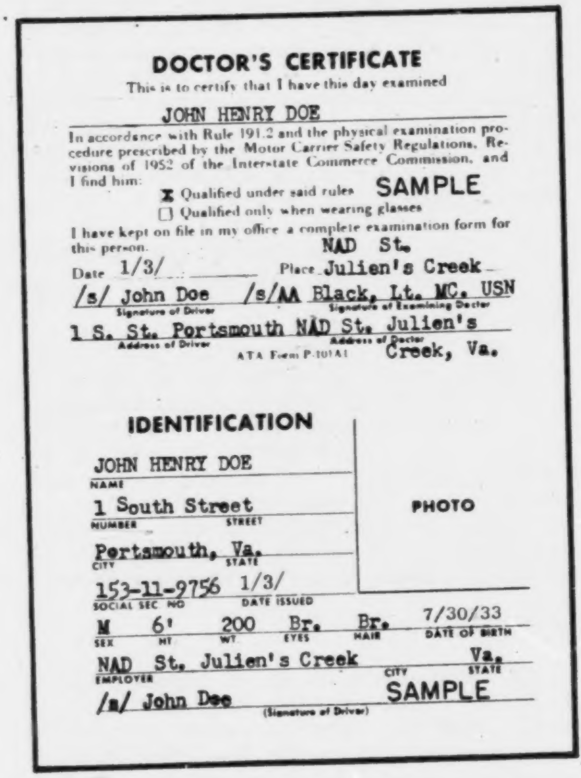
Figure 17-2.—Safety equipment required on vehicles.

DOCTOR'S CERTIFICATE

Every Navy driver will be required to undergo an annual physical examination and, on the basis of such an examination, be certified by a licensed doctor of medicine or osteopathy as meeting the requirements as stated in the Motor Carrier Safety Regulations. On the basis of the prescribed physical examination, successful applicants will be issued a "Doctor's Certificate," ATA Form P-101A1, stating their qualification. Preparation of the doctor's certificate form is the responsibility of each station. It is suggested that the certificate be prepared in wallet size for easy carrying. Figure 17-3 shows a sample form that may be obtained, at nominal cost, from the American Trucking Association, 1616 P St., N.W., Washington, D.C. 20036.

The Explosives Driver must have this doctor's certificate with him while driving. He also is responsible for keeping his certificate current by submitting annually for re-examination. In addition to the copy held by the driver, a certificate or legible photographically reproduced copy of the certificate must be kept in the health record of each individual concerned.



DOCTOR'S CERTIFICATE

This is to certify that I have this day examined

JOHN HENRY DOE

In accordance with Rule 191.2 and the physical examination procedure prescribed by the Motor Carrier Safety Regulations, Revisions of 1952 of the Interstate Commerce Commission, and I find him:

☒ Qualified under said rules SAMPLE

☐ Qualified only when wearing glasses

I have kept on file in my office a complete examination form for this person.

Date 1/3/ Place NAD St. Julien's Creek

/s/ John Doe /s/AA Black, Lt. MC. USN
Signature of Driver Signature of Examining Doctor

1 S. St. Portsmouth NAD St. Julien's Creek, Va.
Address of Driver Address of Doctor

ATA Form P-101A1

IDENTIFICATION

PHOTO

NAME: JOHN HENRY DOE
NUMBER STREET: 1 South Street
CITY STATE: Portsmouth, Va.
SOCIAL SEC NO: 153-11-9756 DATE ISSUED: 1/3/
SEX: M HT: 6' WT: 200 EYES: Br. HAIR: Br. DATE OF BIRTH: 7/30/33
EMPLOYER: NAD St. Julien's Creek CITY STATE: Va.

/s/ John Doe SAMPLE
(Signature of Driver)

115.410

Figure 17-3.—Doctor's Certificate, ATA Form P-101A1.

AGE AND EXPERIENCE

The Navy driver of a truck carrying dangerous cargo on-station must be 18 years of age or over, whereas the off-station driver must be 21 YEARS OF AGE OR OVER. He must have had considerable and varied driving experience with the type of equipment he will be expected to operate, and possess an excellent safe driving record.

MENTAL REQUIREMENTS

All Navy drivers must pass a mental examination administered by the local command before they can be considered as Explosive Drivers. They must be able to read, write, and understand the English language and to complete the various forms for which drivers are responsible.

PHYSICAL REQUIREMENTS

All Navy drivers applying for classification as Explosives Drivers will be required, annually, to pass a thorough physical examination administered by either a military or civilian physician. Special emphasis will be placed on eyesight (the loss of an eye or color blindness will be disqualifying factors), hearing, the heart, and the vascular system, and there must be no loss of limbs or other physical defects or limitations likely to interfere with safe driving.

DISCIPLINARY ACTION AND PENALTIES

Traffic violations or accidents must be reported to the Safety Officer, and will be noted on the driver's permit. The Commanding Officer shall suspend or revoke a Navy driver's permit if, in his opionion, it would be in the best interests of the Navy.

A Navy driver's permit will be suspended or revoked automatically for the following violations, and notice of such action will be filed in the driver's personnel record:

1. Driving under the influence of alcohol or drugs.
2. Failure to report an accident in which the driver was involved.
3. Leaving the scene of an accident in which the driver was involved.
4. Smoking while on a vehicle loaded with dangerous cargo.

Any driver whose permit has been suspended or revoked for any of the above reasons will be required to pass a physical re-examination before he can be re-examined for a new permit. Drivers will be required to pass a driving test given after a waiting period of 3 to 6 months, depending upon the nature of the offense. Reinstatement will be granted only with the permission of the Commanding Officer of the activity.

FORMS AND REPORTS

The following sections describe various forms and reports which will concern you as a driver of vehicles carrying explosives.

DD FORM 626

An "Inspection Report," DD Form 626 (fig. 17-4), is a vehicle inspection form which lists the vital parts to be checked on a truck before it can be qualified as safe for transporting dangerous cargo. The form provides for a mechanical inspection of the truck as well as an inspection of the cargo.

A copy of the inspection report should be given to you with instructions to carry it to your destination. If, for some reason, you do not complete the entire trip but turn your truck and cargo over to another qualified driver, you should give him the DD Form 626 to carry to his destination.

Regulations state that every activity operating a motor vehicle transporting ammunition, explosives, or other dangerous articles must require the driver to have in his possession throughout the course of transporting material, a shipping document showing the following pertinent information for each type or kind of explosive or dangerous article being transported:

1. Hazard and material description.
2. Item nomenclature (example: 3.5 rockets).
3. The total quantity by weight (gross and net), volume, or number, as appropriate, for the type of ammunition, explosives, or other dangerous articles being transported.
4. The prescribed labels, when required, for the outside of the containers.
5. Any other necessary information or instruction.

You will be responsible for the verification of the quantity of each item as specified on each shipping document at the point of origin and at the destination, and must ensure that all shipping documents remain in your possession throughout the trip.

DD FORM 836

"Special Instructions for Motor Vehicle Drivers," DD Form 836 (figure 17-5), must be carried by each driver of military vehicles transporting dangerous cargo over public roads within the continental United States. The information on the form is applicable only to the specific load being transported and is a summary of the various characteristics of the cargo as concerns safety precautions and emergency techniques. The shipping activity originates DD Form 836. Generally, it is the function of the Transportation Officer or Safety Officer.

It is your responsibility to read carefully the information on DD Form 836 and be certain that you understand all the instructions thereon. You then sign the form and carry it with you in transit. In case of emergency, you will use the appropriate information on the form as well as make it available to all local authorities who may wish to assist you. On reaching your destination, you must deliver the form to the receiving activity. If the drivers are changed enroute, the form and the responsibility for the lading are transferred to the new driver who signs the form and, upon completion of the trip, submits it to the receiving activity.

STANDARD FORM 91

An "Operator's Report of Motor Vehicle Accident," Standard Form 91, must be completed each time a Navy vehicle is involved in an accident, no matter how trivial the accident may seem. Detailed information on Standard Form 91 is presented in chapter 5 of this training manual, so repeat coverage will not be given here.

NAVDOCKS FORM 11240/1

A "Vehicle/Equipment Request and Record," NAVFAC Form 11240/1, is completed each day that a Navy vehicle is in use either in on-station or off-station operations.

For detailed information on NAVFAC Form 11240/1, refer to chapter 5 of this training manual.

DD FORM 518

An "Accident Identification Card," DD Form 518 is used to provide any person involved in an accident with a Navy vehicle with the name and organizational assignment of the Navy driver. nformation on DD Form 518 is given in chapter 5 of this book, and the form is illustrated in igure 5-52.

LOADING, HANDLING, AND STORAGE REGULATIONS

Special care must be exercised in the handling, loading, and shipping of ammunition, explosives, or other dangerous articles. Improper handling of a load may result, not only in its malfunctioning later, but in accidents which may cause injuries or deaths.

ALL ammunition, explosives, or other dangerous articles bear a classification; for example: explosive projectiles, Class A; propellant explosives, Class B; and small arms ammunition, Class C. The amounts and types of classes that may be loaded on one truck are specifically prescribed on the basis of weight and compatibility.

Only those materials which are compatible should be loaded as one cargo, and then only in the allowed amounts. (See fig. 17-6.) You must make certain that materials bearing different hazard classifications are properly separated, and that authorized amounts of explosives to be shipped in one load have not been exceeded. THIS, PRIMARILY, IS THE DUTY OF THE INSPECTOR, BUT YOU SHOULD MAKE A VISUAL CHECK AS AN ADDED PRECAUTION.

The chart shown in figure 17-6 indicates the explosives and other dangerous articles which must not be loaded, transported, or stored together. Information included in the chart is derived from the Department of Transportation Regulations that are applicable to the transportation of ammunition, explosives, and other dangerous articles.

Specific directions for using this chart are given in the top left-hand corner of the chart. Footnotes appear at the bottom of the chart.

In addition to the specific directions and footnotes, the following notes apply:

Note 1: When separate Class A detonating fuzes (not assembled in the ammunition or in items listed or packed in the same outside container) are loaded in a railroad car or vehicle with bombs, projectiles, depth charges, mines, boosters, or torpedoes (warheads), the fuzes must be separated from them by a 3-foot space. This space should be filled with dry sand or dry earth contained either in bags or in a crib. If a crib is used, it must be secured against movement and constructed or lined so that there can be no sifting.

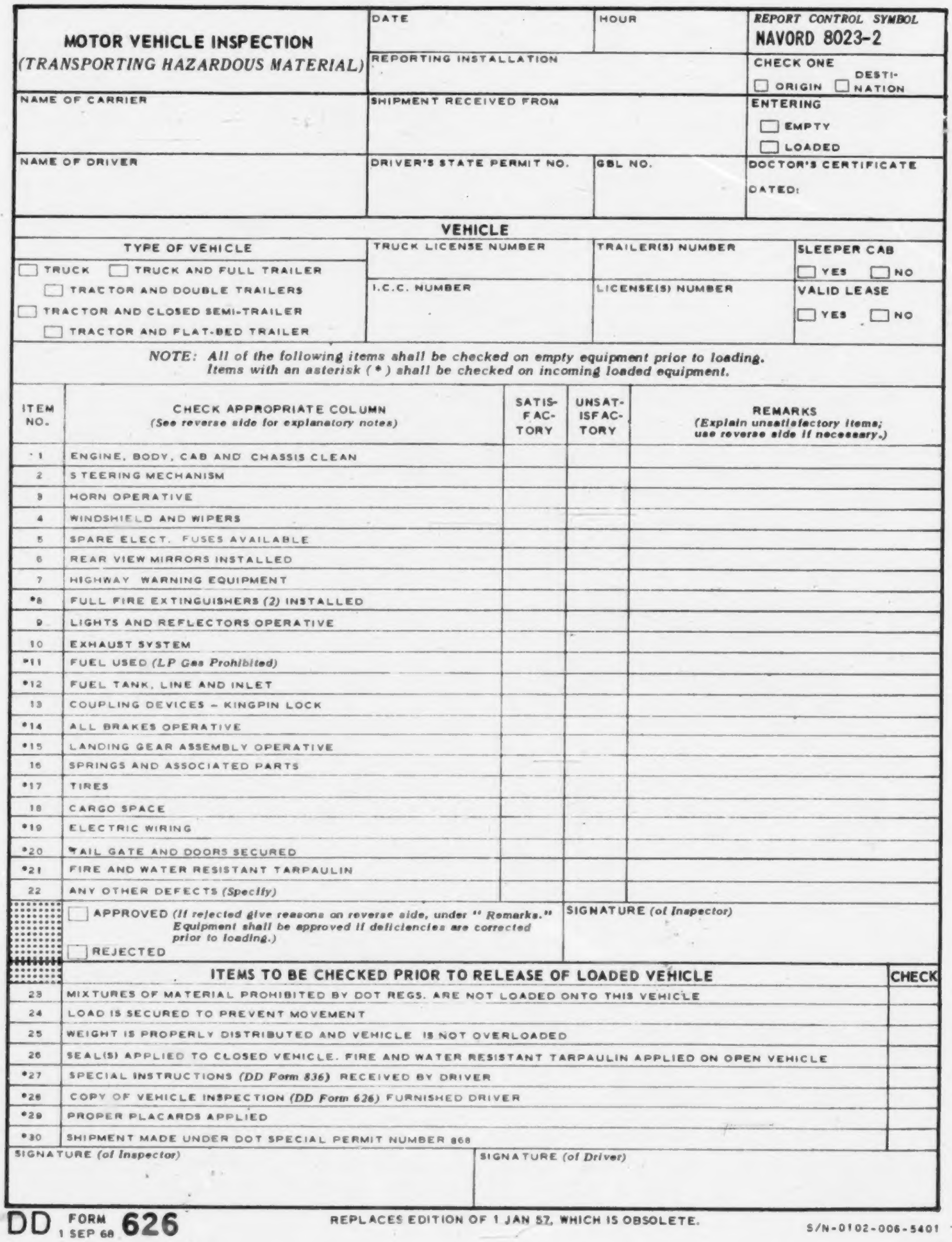
Note 2: Chemical ammunition containing incendiary charges or white phosphorus must not be loaded with Class A or B explosives.

Note 3: Smokeless powder for small arms in quantities not exceeding 100 pounds net weight in one car will be classed as flammable solid for purposes of transportation when approved for such classification by the Bureau of Explosives.

CARGO HANDLING PRECAUTIONS

During loading, packages or containers of ammunition, explosives, or other dangerous articles must be placed carefully in the vehicle and located so as to prevent sliding, falling, or shifting during transit. (See fig. 17-7.)

Proper handling during unloading operations will be carried on under the direction of qualified supervisory personnel. Packages or containers of ammunition, explosives, and other dangerous articles unloaded from a truck must be placed a sufficient distance from the exhaust of the vehicle to prevent danger so engine sparks igniting the material when the motor is restarted. Packages or containers must not be thrown, dropped,



MOTOR VEHICLE INSPECTION
(TRANSPORTING HAZARDOUS MATERIAL)

DATE
HOUR
REPORT CONTROL SYMBOL NAVORD 8023-2
REPORTING INSTALLATION
CHECK ONE ☐ ORIGIN ☐ DESTINATION
NAME OF CARRIER
SHIPMENT RECEIVED FROM
ENTERING ☐ EMPTY ☐ LOADED
NAME OF DRIVER
DRIVER'S STATE PERMIT NO.
GBL NO.
DOCTOR'S CERTIFICATE DATED:

VEHICLE

TYPE OF VEHICLE
☐ TRUCK ☐ TRUCK AND FULL TRAILER
☐ TRACTOR AND DOUBLE TRAILERS
☐ TRACTOR AND CLOSED SEMI-TRAILER
☐ TRACTOR AND FLAT-BED TRAILER

TRUCK LICENSE NUMBER
TRAILER(S) NUMBER
SLEEPER CAB ☐ YES ☐ NO
I.C.C. NUMBER
LICENSE(S) NUMBER
VALID LEASE ☐ YES ☐ NO

NOTE: All of the following items shall be checked on empty equipment prior to loading. Items with an asterisk (*) shall be checked on incoming loaded equipment.

ITEM NO.	CHECK APPROPRIATE COLUMN *(See reverse side for explanatory notes)*	SATISFACTORY	UNSATISFACTORY	REMARKS *(Explain unsatisfactory items; use reverse side if necessary.)*
*1	ENGINE, BODY, CAB AND CHASSIS CLEAN			
2	STEERING MECHANISM			
3	HORN OPERATIVE			
4	WINDSHIELD AND WIPERS			
5	SPARE ELECT. FUSES AVAILABLE			
6	REAR VIEW MIRRORS INSTALLED			
7	HIGHWAY WARNING EQUIPMENT			
*8	FULL FIRE EXTINGUISHERS *(2)* INSTALLED			
9	LIGHTS AND REFLECTORS OPERATIVE			
10	EXHAUST SYSTEM			
*11	FUEL USED *(LP Gas Prohibited)*			
*12	FUEL TANK, LINE AND INLET			
13	COUPLING DEVICES – KINGPIN LOCK			
*14	ALL BRAKES OPERATIVE			
*15	LANDING GEAR ASSEMBLY OPERATIVE			
16	SPRINGS AND ASSOCIATED PARTS			
*17	TIRES			
18	CARGO SPACE			
*19	ELECTRIC WIRING			
*20	TAIL GATE AND DOORS SECURED			
*21	FIRE AND WATER RESISTANT TARPAULIN			
22	ANY OTHER DEFECTS *(Specify)*			

☐ APPROVED *(If rejected give reasons on reverse side, under "Remarks." Equipment shall be approved if deficiencies are corrected prior to loading.)*
☐ REJECTED

SIGNATURE *(of Inspector)*

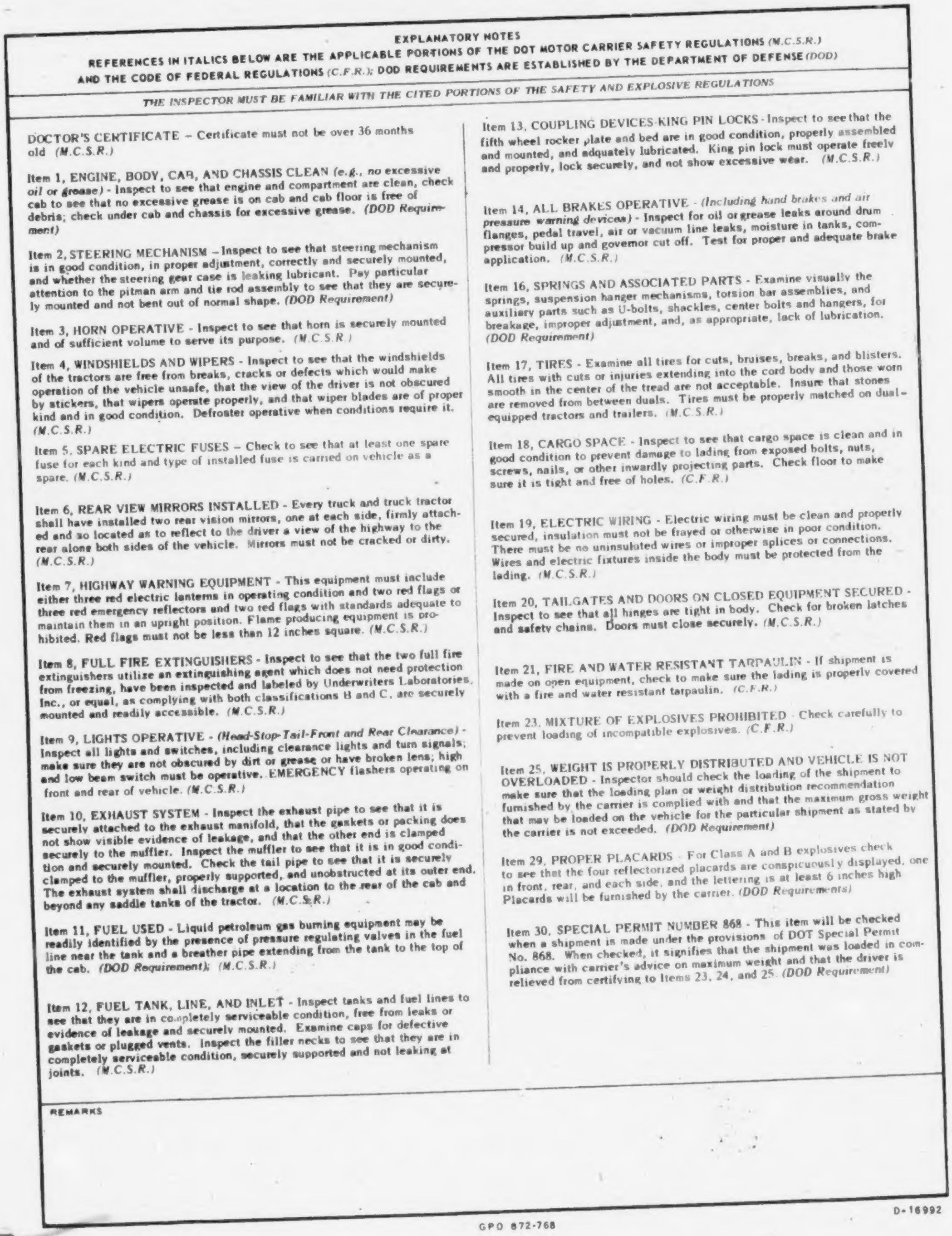
	ITEMS TO BE CHECKED PRIOR TO RELEASE OF LOADED VEHICLE	CHECK
23	MIXTURES OF MATERIAL PROHIBITED BY DOT REGS. ARE NOT LOADED ONTO THIS VEHICLE	
24	LOAD IS SECURED TO PREVENT MOVEMENT	
25	WEIGHT IS PROPERLY DISTRIBUTED AND VEHICLE IS NOT OVERLOADED	
26	SEAL(S) APPLIED TO CLOSED VEHICLE. FIRE AND WATER RESISTANT TARPAULIN APPLIED ON OPEN VEHICLE	
*27	SPECIAL INSTRUCTIONS *(DD Form 836)* RECEIVED BY DRIVER	
*28	COPY OF VEHICLE INSPECTION *(DD Form 626)* FURNISHED DRIVER	
*29	PROPER PLACARDS APPLIED	
*30	SHIPMENT MADE UNDER DOT SPECIAL PERMIT NUMBER 868	

SIGNATURE *(of Inspector)*
SIGNATURE *(of Driver)*

DD FORM 1 SEP 68 626
REPLACES EDITION OF 1 JAN 57, WHICH IS OBSOLETE.
S/N-0102-006-5401

115.411.1

Figure 17-4.—Inspection Report, DD Form 626, (front).



EXPLANATORY NOTES

REFERENCES IN ITALICS BELOW ARE THE APPLICABLE PORTIONS OF THE DOT MOTOR CARRIER SAFETY REGULATIONS *(M.C.S.R.)* **AND THE CODE OF FEDERAL REGULATIONS** *(C.F.R.)*; **DOD REQUIREMENTS ARE ESTABLISHED BY THE DEPARTMENT OF DEFENSE** *(DOD)*

THE INSPECTOR MUST BE FAMILIAR WITH THE CITED PORTIONS OF THE SAFETY AND EXPLOSIVE REGULATIONS

DOCTOR'S CERTIFICATE – Certificate must not be over 36 months old *(M.C.S.R.)*

Item 1, ENGINE, BODY, CAB, AND CHASSIS CLEAN *(e.g., no excessive oil or grease)* - Inspect to see that engine and compartment are clean, check cab to see that no excessive grease is on cab and cab floor is free of debris; check under cab and chassis for excessive grease. *(DOD Requirement)*

Item 2, STEERING MECHANISM – Inspect to see that steering mechanism is in good condition, in proper adjustment, correctly and securely mounted, and whether the steering gear case is leaking lubricant. Pay particular attention to the pitman arm and tie rod assembly to see that they are securely mounted and not bent out of normal shape. *(DOD Requirement)*

Item 3, HORN OPERATIVE - Inspect to see that horn is securely mounted and of sufficient volume to serve its purpose. *(M.C.S.R.)*

Item 4, WINDSHIELDS AND WIPERS - Inspect to see that the windshields of the tractors are free from breaks, cracks or defects which would make operation of the vehicle unsafe, that the view of the driver is not obscured by stickers, that wipers operate properly, and that wiper blades are of proper kind and in good condition. Defroster operative when conditions require it. *(M.C.S.R.)*

Item 5, SPARE ELECTRIC FUSES – Check to see that at least one spare fuse for each kind and type of installed fuse is carried on vehicle as a spare. *(M.C.S.R.)*

Item 6, REAR VIEW MIRRORS INSTALLED - Every truck and truck tractor shall have installed two rear vision mirrors, one at each side, firmly attached and so located as to reflect to the driver a view of the highway to the rear alone both sides of the vehicle. Mirrors must not be cracked or dirty. *(M.C.S.R.)*

Item 7, HIGHWAY WARNING EQUIPMENT - This equipment must include either three red electric lanterns in operating condition and two red flags or three red emergency reflectors and two red flags with standards adequate to maintain them in an upright position. Flame producing equipment is prohibited. Red flags must not be less than 12 inches square. *(M.C.S.R.)*

Item 8, FULL FIRE EXTINGUISHERS - Inspect to see that the two full fire extinguishers utilize an extinguishing agent which does not need protection from freezing, have been inspected and labeled by Underwriters Laboratories, Inc., or equal, as complying with both classifications B and C, are securely mounted and readily accessible. *(M.C.S.R.)*

Item 9, LIGHTS OPERATIVE - *(Head-Stop-Tail-Front and Rear Clearance)* - Inspect all lights and switches, including clearance lights and turn signals; make sure they are not obscured by dirt or grease or have broken lens; high and low beam switch must be operative. EMERGENCY flashers operating on front and rear of vehicle. *(M.C.S.R.)*

Item 10, EXHAUST SYSTEM - Inspect the exhaust pipe to see that it is securely attached to the exhaust manifold, that the gaskets or packing does not show visible evidence of leakage, and that the other end is clamped securely to the muffler. Inspect the muffler to see that it is in good condition and securely mounted. Check the tail pipe to see that it is securely clamped to the muffler, properly supported, and unobstructed at its outer end. The exhaust system shall discharge at a location to the rear of the cab and beyond any saddle tanks of the tractor. *(M.C.S.R.)*

Item 11, FUEL USED - Liquid petroleum gas burning equipment may be readily identified by the presence of pressure regulating valves in the fuel line near the tank and a breather pipe extending from the tank to the top of the cab. *(DOD Requirement)*; *(M.C.S.R.)*

Item 12, FUEL TANK, LINE, AND INLET - Inspect tanks and fuel lines to see that they are in completely serviceable condition, free from leaks or evidence of leakage and securely mounted. Examine caps for defective gaskets or plugged vents. Inspect the filler necks to see that they are in completely serviceable condition, securely supported and not leaking at joints. *(M.C.S.R.)*

Item 13, COUPLING DEVICES-KING PIN LOCKS - Inspect to see that the fifth wheel rocker plate and bed are in good condition, properly assembled and mounted, and adquately lubricated. King pin lock must operate freely and properly, lock securely, and not show excessive wear. *(M.C.S.R.)*

Item 14, ALL BRAKES OPERATIVE - *(Including hand brakes and air pressure warning devices)* - Inspect for oil or grease leaks around drum flanges, pedal travel, air or vacuum line leaks, moisture in tanks, compressor build up and governor cut off. Test for proper and adequate brake application. *(M.C.S.R.)*

Item 16, SPRINGS AND ASSOCIATED PARTS - Examine visually the springs, suspension hanger mechanisms, torsion bar assemblies, and auxiliary parts such as U-bolts, shackles, center bolts and hangers, for breakage, improper adjustment, and, as appropriate, lack of lubrication. *(DOD Requirement)*

Item 17, TIRES - Examine all tires for cuts, bruises, breaks, and blisters. All tires with cuts or injuries extending into the cord body and those worn smooth in the center of the tread are not acceptable. Insure that stones are removed from between duals. Tires must be properly matched on dual-equipped tractors and trailers. *(M.C.S.R.)*

Item 18, CARGO SPACE - Inspect to see that cargo space is clean and in good condition to prevent damage to lading from exposed bolts, nuts, screws, nails, or other inwardly projecting parts. Check floor to make sure it is tight and free of holes. *(C.F.R.)*

Item 19, ELECTRIC WIRING - Electric wiring must be clean and properly secured, insulation must not be frayed or otherwise in poor condition. There must be no uninsulated wires or improper splices or connections. Wires and electric fixtures inside the body must be protected from the lading. *(M.C.S.R.)*

Item 20, TAILGATES AND DOORS ON CLOSED EQUIPMENT SECURED - Inspect to see that all hinges are tight in body. Check for broken latches and safety chains. Doors must close securely. *(M.C.S.R.)*

Item 21, FIRE AND WATER RESISTANT TARPAULIN - If shipment is made on open equipment, check to make sure the lading is properly covered with a fire and water resistant tarpaulin. *(C.F.R.)*

Item 23, MIXTURE OF EXPLOSIVES PROHIBITED - Check carefully to prevent loading of incompatible explosives. *(C.F.R.)*

Item 25, WEIGHT IS PROPERLY DISTRIBUTED AND VEHICLE IS NOT OVERLOADED - Inspector should check the loading of the shipment to make sure that the loading plan or weight distribution recommendation furnished by the carrier is complied with and that the maximum gross weight that may be loaded on the vehicle for the particular shipment as stated by the carrier is not exceeded. *(DOD Requirement)*

Item 29, PROPER PLACARDS - For Class A and B explosives check to see that the four reflectorized placards are conspicuously displayed, one in front, rear, and each side, and the lettering is at least 6 inches high Placards will be furnished by the carrier. *(DOD Requirements)*

Item 30, SPECIAL PERMIT NUMBER 868 - This item will be checked when a shipment is made under the provisions of DOT Special Permit No. 868. When checked, it signifies that the shipment was loaded in compliance with carrier's advice on maximum weight and that the driver is relieved from certifying to Items 23, 24, and 25. *(DOD Requirement)*

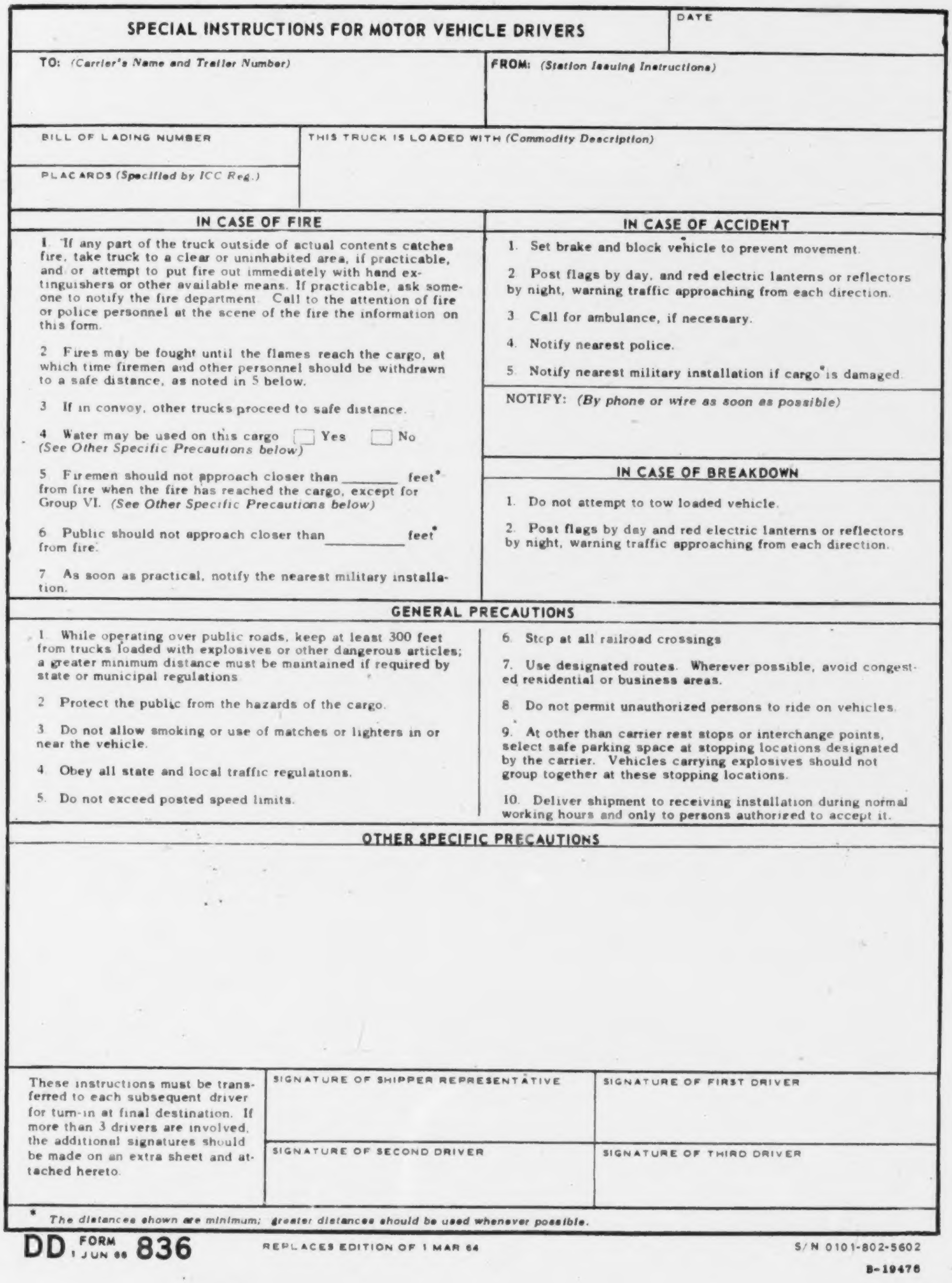
REMARKS

D-16992

GPO 872-768

115.411.2

Figure 17-4.—Inspection Report, DD Form 626, (back).



SPECIAL INSTRUCTIONS FOR MOTOR VEHICLE DRIVERS	DATE
TO: *(Carrier's Name and Trailer Number)*	FROM: *(Station Issuing Instructions)*
BILL OF LADING NUMBER	THIS TRUCK IS LOADED WITH *(Commodity Description)*
PLACARDS *(Specified by ICC Reg.)*	

IN CASE OF FIRE

1. If any part of the truck outside of actual contents catches fire, take truck to a clear or uninhabited area, if practicable, and or attempt to put fire out immediately with hand extinguishers or other available means. If practicable, ask someone to notify the fire department. Call to the attention of fire or police personnel at the scene of the fire the information on this form.
2. Fires may be fought until the flames reach the cargo, at which time firemen and other personnel should be withdrawn to a safe distance, as noted in 5 below.
3. If in convoy, other trucks proceed to safe distance.
4. Water may be used on this cargo ☐ Yes ☐ No *(See Other Specific Precautions below)*
5. Firemen should not approach closer than ________ feet* from fire when the fire has reached the cargo, except for Group VI. *(See Other Specific Precautions below)*
6. Public should not approach closer than __________ feet* from fire.
7. As soon as practical, notify the nearest military installation.

IN CASE OF ACCIDENT

1. Set brake and block vehicle to prevent movement.
2. Post flags by day, and red electric lanterns or reflectors by night, warning traffic approaching from each direction.
3. Call for ambulance, if necessary.
4. Notify nearest police.
5. Notify nearest military installation if cargo is damaged.

NOTIFY: *(By phone or wire as soon as possible)*

IN CASE OF BREAKDOWN

1. Do not attempt to tow loaded vehicle.
2. Post flags by day and red electric lanterns or reflectors by night, warning traffic approaching from each direction.

GENERAL PRECAUTIONS

1. While operating over public roads, keep at least 300 feet from trucks loaded with explosives or other dangerous articles; a greater minimum distance must be maintained if required by state or municipal regulations.
2. Protect the public from the hazards of the cargo.
3. Do not allow smoking or use of matches or lighters in or near the vehicle.
4. Obey all state and local traffic regulations.
5. Do not exceed posted speed limits.
6. Stop at all railroad crossings.
7. Use designated routes. Wherever possible, avoid congested residential or business areas.
8. Do not permit unauthorized persons to ride on vehicles.
9. At other than carrier rest stops or interchange points, select safe parking space at stopping locations designated by the carrier. Vehicles carrying explosives should not group together at these stopping locations.
10. Deliver shipment to receiving installation during normal working hours and only to persons authorized to accept it.

OTHER SPECIFIC PRECAUTIONS

These instructions must be transferred to each subsequent driver for turn-in at final destination. If more than 3 drivers are involved, the additional signatures should be made on an extra sheet and attached hereto.	SIGNATURE OF SHIPPER REPRESENTATIVE	SIGNATURE OF FIRST DRIVER
	SIGNATURE OF SECOND DRIVER	SIGNATURE OF THIRD DRIVER

* *The distances shown are minimum; greater distances should be used whenever possible.*

DD FORM 1 JUN 68 836 REPLACES EDITION OF 1 MAR 64 S/N 0101-802-5602

B-19476

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Figure 17-5.—Special Instructions for Motor Vehicle Drivers, DD Form 836.

The following table shows the explosives and other dangerous articles which must not be loaded or stored together.
The letter X at an intersection of horizontal and vertical columns shows that these articles must not be loaded or stored together, for example: detonating fuses class A, with or without radioactive components g horizontal column must not be loaded or stored with high explosives or propellant explosives, class A b vertical column.

		Low explosives or black powder	High explosives or propellant explosives, class A	Initiating or priming explosives, wet: Diazodinitrophenol, fulminate of mercury, guanyl, nitrosamino guanylidene hydrazine, lead azide, lead styphnate, nitro mannite, nitrosoguanidine, pentaerythrite tetranitrate, tetrazene, lead mononitroresorcinate.	Blasting caps, with or without safety fuse (including electric blasting caps), detonating primers	Ammunition for cannon with explosive projectiles, gas projectiles, smoke projectiles, incendiary projectiles, illuminating projectiles or shell, ammunition for small arms with explosive bullets, or ammunition for small arms with explosive projectiles, or rocket ammunition with explosive projectiles, gas projectiles, smoke projectiles, incendiary projectiles, illuminating projectiles; and boosters (explosive), bursters (explosive), or supplementary charges (explosive) without detonators, [c], [d]	Explosive projectiles, bombs, torpedoes, or mines, rifle or hand grenades (explosive), jet thrust units (jato), explosive, class A, or igniters, jet thrust (jato), explosive, class A [e]	Detonating fuses, class A, with or without radioactive components	Ammunition for cannon with empty, inert-loaded or solid projectiles, or without projectiles, or rocket ammunition with empty projectiles, inert-loaded or solid projectiles or without projectiles	Propellant explosives, class B, jet thrust units (jato), class B, igniters, jet thrust (jato), class B, or starter cartridges, jet engine, class B	Fireworks, special or railway torpedoes	Small arms ammunition	Primers for cannon or small arms, empty cartridge bags—black powder igniters, empty cartridge cases, primed, empty grenades, primed, combination primers or percussion caps, toy caps, explosive cable cutters, explosive rivets	Percussion fuses, tracer fuses or tracers	Time, combination or detonating fuses, class C	Cordeau detonant fuse, safety squibs, fuse lighters, fuse igniters, delay electric igniters, electric squibs, instantaneous fuse or igniter cord	Fireworks, common, highway fusees or railway fusees	Flammable liquids or compressed flammable gases, red label	Flammable solids or oxidizing materials, yellow label	Acids or corrosive liquids, white label	Compressed nonflammable gases, green label	Poisonous gases or liquids, in cylinders, projectiles or bombs, poison gas label	Radioactive materials (class D poisons)
		a	b	c	d	e	f	g	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLASS A EXPLOSIVES																							
Low explosives or black powder	a			X							X						X	X	X	X	X	X	X
High explosives or propellant explosives, class A	b			X	X			X			X						X	X	[e] X	X	X	X	X
Initiating or priming explosives, wet: Diazodinitrophenol, fulminate of mercury, guanyl, nitrosamino guanylidene hydrazine, lead azide, lead styphnate, nitro mannite, nitrosoguanidine, pentaerythrite tetranitrate, tetrazene, lead mononitroresorcinate.	c	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Blasting caps, with or without safety fuse (including electric blasting caps), detonating primers	d		X	X		X	X				[a] X						[a] X	[a] X	[a] [e] X	[a] X	[a] X	X	X
Ammunition for cannon with explosive projectiles, gas projectiles, smoke projectiles, incendiary projectiles, illuminating projectiles or shell, ammunition for small arms with explosive bullets, or ammunition for small arms with explosive projectiles, or rocket ammunition with explosive projectiles, gas projectiles, smoke projectiles, incendiary projectiles, illuminating projectiles; and boosters (explosive), bursters (explosive), or supplementary charges (explosive) without detonators, [c], [d]	e			X	X			X			X						X	X	X	X	X	X	X
Explosive projectiles, bombs, torpedoes, or mines, rifle or hand grenades (explosive), jet thrust units (jato), explosive, class A, or igniters, jet thrust (jato), explosive, class A [e]	f			X	X			X			X						X	X	X	X	X	X	X
Detonating fuses, class A, with or without radioactive components	g		X	X		X	X				X						X	X	X	X	X	X	X
CLASS B EXPLOSIVES																							
Ammunition for cannon with empty, inert-loaded or solid projectiles, or without projectiles, or rocket ammunition with empty projectiles, inert-loaded or solid projectiles or without projectiles	1			X																[b] X		X	
Propellant explosives, class B, jet thrust units (jato), class B, igniters, jet thrust (jato), class B, or starter cartridges, jet engine, class B	2			X																[b] X		X	
Fireworks, special, or railway torpedoes	3	X	X	X	[a] X	X	X	X														X	
CLASS C EXPLOSIVES																							
Small arms ammunition	4			X																			
Primers for cannon or small arms, empty cartridge bags—black powder igniters, empty cartridge cases, primed, empty grenades, primed, combination primers or percussion caps, toy caps, explosive cable cutters, explosive rivets	5			X																			
Percussion fuses, tracer fuses or tracers	6			X																			
Time, combination or detonating fuses, class C	7			X																			
Cordeau detonant fuse, safety squibs, fuse lighters, fuse igniters, delay electric igniters, electric squibs, instantaneous fuse or igniter cord	8			X																			
Fireworks, common, highway fusees or railway fusees	9	X	X	X	[a] X	X	X	X														X	
OTHER DANGEROUS ARTICLES																							
Flammable liquids or compressed flammable gases, red label	10	X	X	X	[a] X	X	X	X														X	
Flammable solids or oxidizing materials, yellow label	11	X	[e] X	X	[a] [e] X	X	X	X												[b] X		X	
Acids or corrosive liquids, white label	12	X	X	X	[a] X	X	X	X	[b] X	[b] X									[b] X			X	
Compressed nonflammable gases, green label	13	X	X	X	[a] X	X	X	X															
Poisonous gases or liquids, in cylinders, projectiles or bombs, poison gas label	14	X	X	X	X	X	X	X	X	X	X						X	X	X	X			
Radioactive materials (class D poisons)	15	X	X	X	X	X	X	X															

[a] Blasting caps or electric blasting caps in quantities not exceeding 1,000 caps may also be loaded and transported with articles named in vertical and horizontal columns 3, 9, 10, 11, 12 and 13. Loading and transportation of blasting caps or electric blasting caps in any quantity with articles named in vertical or horizontal columns b, c, e or f is prohibited.

[b] Unless loaded in opposite ends of car, acids or other corrosive liquids, white label, must not be loaded with yellow label articles, ammunition for cannon with or without projectiles, or propellant explosives, except that shippers loading carload shipments of white label and yellow label articles and who have obtained prior approval from the Bureau of Explosives may load such articles together when it is known that the mixture of contents will not cause a dangerous evolution of heat or gas.

[7][c] Explosives, class A and explosives, class B must not be loaded or stored with chemical ammunition containing incendiary charges or white phosphorus either with or without bursting charges.

[d] Bursters (explosive), boosters (explosive), or supplementary charges (explosive) without detonators when shipped by, to or for the Departments of the Army, Navy, and Air Force of the United States Government may be loaded with any of the articles named except those in columns, c, d, 3, 9, 10, 11, 12, 13, 14, and 15.

[e] Does not include nitro carbo nitrate or ammonium nitrate, fertilizer grade, which may be loaded, transported or stored with high explosives or with blasting caps or electric blasting caps, and detonating primers.

NOTE 1: Charged electric storage batteries must not be loaded in the same car nor stored with any class A explosive.

NOTE 2: Cyanides or cyanide mixtures must not be loaded or stored with acids or corrosive liquids.

NOTE 3: Gas identification sets may be loaded and transported with all articles named except those in column c.

NOTE 4: Nitric acid, when loaded in the same car with other acids or other corrosive liquids in carboys, must be separated from the other carboys. A 2 by 6 inch plank, set on edge, should be nailed across the car floor at least 12 inches from the nitric acid carboys, and the space between the plank and the carboys of nitric acid should be filled with sand, sifted ashes, or other incombustible absorbent material.

[1]NOTE 5: Smokeless powder for small arms in quantities not exceeding 100 pounds net weight in one car shall be classed as flammable solid for purposes of transportation when approved for such classification by the Bureau of Explosives.

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[7] Amended, effective July 7, 1965.

[1] Added, effective March 17, 1964. [2] Amended, effective March 18, 1964.

slid, pulled, or tumbled while being loaded and/or unloaded.

During loading and unloading operations, the driver must ensure that:

1. The engine is shut off.
2. The handbrake is securely set, the wheels are blocked, and the power unit is in the lowest forward or reverse gear.
3. Extreme care is taken to keep away and to prevent persons in the vicinity from smoking, lighting matches, or carrying any flame or lighted cigar, pipe, or cigarette.
4. Only nonferrous metal equipment is used.
5. In loading, the interior of the body is free from any inwardly projecting parts such as bolts, screws, or nails.
6. In loading, the floor of the vehicle is tight and lined with either nonmetallic material or nonferrous metals.

You will be responsible for checking the following items of inspection before moving your loaded truck:

1. Containers. You must inspect the lading to ensure that no containers are leaking, broken, or appear so weak that breakage could occur during normal shipment.
2. Quantity. This is the dispatcher's responsibility, but you must verify that the total quantity of the load to be shipped is within the specified maximum limits for weight and contents. You must also ensure that the load does not exceed the weight limitations of the states through which the shipment is being routed.
3. Proper Bracing and Blocking of Load. You must inspect the load to ensure that it is braced and blocked securely and will not shift during transit.
4. Cargo Identification. You must inspect the shipping document and compare it with placards on the truck. The government bill of lading shows the required placards. It is your duty to be certain that the truck is placarded in compliance with Department of Transportation Regulations for the shipment of ammunition, explosives, or other dangerous articles, according to the type of material being transported.
5. Vehicle Sealing. You must be certain before you move the vehicle that it is not only properly placarded but that it is closed, secured, and sealed.

SPECIAL LOADS

When specifically authorized by the Ordnance Systems Command, small quantities of blasting caps and similar detonating devices may be shipped by motor vehicle with materials subject to detonation. However, the detonating device must be transported in the cab of the truck and the remainder of the materials in the cargo space. This regulation is not intended to prohibit carrying on one truck complete rounds of ammunition including fuzes and primers.

When limited amounts of ammunition, explosives, or other dangerous materials for testing purposes are transported in Navy trucks, many of the restrictions imposed for normal shipments of such material are modified. These modifications are approved by the Ordnance Systems Command only for shipments of samples. The following specific regulations must be strictly enforced:

1. A single load of high explosive samples must not exceed 2,000 pounds.
2. Samples of dangerous material must not be transported with other cargo of incompatible nature.
3. Projectiles, bombs, boxed ammunition, and boxed explosives should be stowed securely in place with appropriate dunnage.
4. Boosters, fuzes, primers, and other such components should be packed separately and securely so that they cannot move. If they are to be transported in the same truck with projectiles, bombs, or other high explosives, each box of components must be shipped inside a larger box constructed of wood at least 1 inch thick and lined with at least 3 inches of mineral wool or similar inert, noncombustible material on the four sides, top, and bottom.
5. Detonators and blasting caps, when required to be shipped on the same truck with high explosives, loaded bombs, or similar articles, will be limited to small quantities specifically approved by the Ordnance Systems Command. They must be packed in special steel containers capable of confining the force of explosion without disruption or fragmentation of the container. This container must be packed in a larger outside wooden box with sand or noncombustible inert cushioning material surrounding the special container on the four sides, top, and bottom. Containers must be braced within the vehicle to prevent any movement and must be separated from the high explosive material.

115.414
Figure 17-7.—Handle dangerous cargo carefully.

6. Component boxes loaded in the same truck body with material such as projectiles or bombs must be separated from them by empty boxes or suitable dunnage so that, in the event of a collision, the component unit will be protected.

7. A truck transporting sample material will have two drivers if the trip is 8 hours duration of more, and must never be left unattended.

BEFORE MOVEMENT INSPECTION

You will have primary responsibility for the safe and efficient transportation of the shipment of ammunition, explosives, or other dangerous articles. In addition to this primary responsibility, you will share with the equipment and loading inspectors the responsibility for the mechanical condition of your vehicle and for the proper loading, compatibility of loading, and security of the vehicle and cargo. Refer to figure 17-8 for general guidance in vehicle inspection.

For outgoing inspections, DD Form 626 (fig. 17-4), must be approved and signed by you, as well as by the equipment inspector and the loading inspector. Any items not approved by the inspectors or you must be corrected before the truck is loaded or moved. You have the right to refuse the truck when, in your opinion, the vehicle is in an unsafe condition for transporting dangerous cargo. Only after you complete the checklist to your own satisfaction should you sign DD Form 626 and move the vehicle. You can check and sign for items 4 through 32 of DD Form 626 when a station does not have qualified personnel to perform the inspection.

For incoming inspections, DD Form 626 will be completed the second time, checking only items 1, 8, 10, 12, 17, and 22 at the receiving point. Vehicles must be stopped at all specified check points enroute, and at intervals of 50 miles or within 2 hours driving time, for inspection. These stops must be made outside the limits of municipalities, away from occupied buildings, and only at points where the vehicle can be parked completely off the highway.

The truck and cargo should be inspected by you for the following:

1. General condition of the truck.
2. Condition of the tires. A soft, flat, or unusually hot tire must be replaced.
3. Stability of the load. If the load appears to have shifted, further inspection should be made. When any deficiency noted has been corrected, the vehicle can then proceed to its assigned destination.

VEHICLE PLACARDS

It will be your responsibility, as driver of a truck loaded with dangerous cargo, to be certain that appropriate cargo placards (as indicated on DD Form 836 as applicable to the shipment) have been affixed to your vehicle before it is moved. (See fig. 17-9.) Table 17-1 gives the appropriate placard for the type of cargo being carried.

Except for "EXPLOSIVES A" and "EXPLOSIVES B" placards, each marking or placard will consist of letters not less than 4 inches high; the "EXPLOSIVES A" and "EXPLOSIVES B" placards must have letters at least 6 inches high. The placard must be larger than its lettering by at least 1 inch at the top, bottom, and sides. The marking or placard should be placed in an area on the vehicle which has no other marking, lettering, or graphic display for at least 3 inches in each direction. Placards or markings must be displayed on the front, rear, and each side of the vehicle. The front marking or placard may be on the front of either the truck, truck body, truck tractor, or trailer. Red-reflecting placards may be used on the front.

Every motor vehicle transporting Class A explosives, Class B explosives, flammables, oxidizing materials, corrosive liquids, compressed gases, poisons, or radioactive materials off-station or on-station must be properly placarded. Red flags may also be used if required by local regulations. On-station vehicles engaged in towing explosive-loaded bomb trailers must be appropriately placarded and the trailer must display red flags. Vehicles towing such equipment are exempt from the requirement for driver fire-fighting instructions as defined herein, and the requirement for additional safety equipment other than fire extinguishers. This exemption applies only as stated above and is NOT applicable to on-station tractor-trailer operations.

VEHICLE ROUTES

Prior to departing from your station, you will be given your prescribed route. The route, established by the cognizant station authority, will not be changed except in case of emergency. Deviations should not be made except:

1. On the direct orders of local law enforcement authorities.
2. Following accidents and breakdowns in which the truck has suffered damage sufficient to justify towing, after unloading, to another locality.
3. On the direct order of the Commanding Officer, Safety Officer, or Ordnance Officer or their designated representatives.
4. When dangerous electrical storms are encountered.
5. When detours have been established by traffic authorities.

DRIVING HAZARDS

While the transportation of dangerous cargo by any method is extremely hazardous, the dangers of transporting by motor vehicle are increased because of the high rate of highway accidents. All rules for road safety should be carefully studied and practiced by operators of motor vehicles carrying ammunition, explosives, or other dangerous articles. Some of the move common hazards may be avoided or minimized through attention to the following information.

CARBON MONOXIDE

Carbon monoxide is a deadly gas which kills quickly and without warning if inhaled in large quantities. In small amounts, it causes drowsiness which results in dangerous inattention by the driver on the highways. The following safety measures should be taken by you to help prevent carbon monoxide gas from escaping into your truck:

1. The engine must be kept in good condition. Motors and undercarriages should be kept free of excessive oil and grease.
2. The manifold should be inspected for leaks in the parts, the exhaust pipe, and the muffler.
3. The cab heater should be carefully checked against gas leaks.
4. One window of the cab should be kept open sufficiently to allow a continuous flow of fresh air.
5. Other vehicles must not be followed so closely that fumes from the exhaust may drift into the cab of your vehicle.

DAMAGE TO CARGO

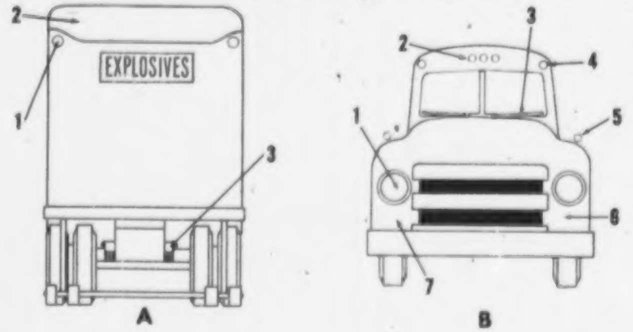
One of the principal reasons for the close inspection of containers loaded with dangerous cargo is to avoid the hazards of fire and explosion. A leaking or broken container of corrosives or acids can injure you by causing burns, fume poisoning, or suffocation. Fires and explosives may also result from careless handling or shifting of an improperly dunnaged load. You must also avoid sharp braking in downhill travel, which is one of the principal causes of load shifting and which usually results in damage to the cargo.

WEATHER CONDITIONS

You must exercise extra caution when hazardous conditions, such as those caused by snow, ice, sleet, fog, and rain, affect visibility or traction. If conditions become extremely hazardous, operation of the vehicle should be temporarily discontinued, after driving to the nearest point that affords safe parking for trucks carrying dangerous cargo.

SPEED REGULATIONS

A motor vehicle must not be driven recklessly or in such a manner as to endanger life, limb, or property. No vehicle may be driven at a greater speed than is reasonable and prudent, with due regard for the type of truck, visibility, traffic and road conditions.



A

1. Front clearance lamps color: AMBER. (SEC. 193.14) Should be operative, clean, and free of all cracks.

2. A fire resistant and waterproof tarpaulin must be carried on all open equipment. (SEC. 77.835(n)DAT)

3. Springs, suspension hanger mechanism, tension bar assemblies and auxiliary parts should be in good condition and properly lubricated. (DOD)

B

1. Headlights shall number at least two and be in good operating condition including the high--low beam. (MCSR 193.13)

2. Identification lamps. MCSR 193.13

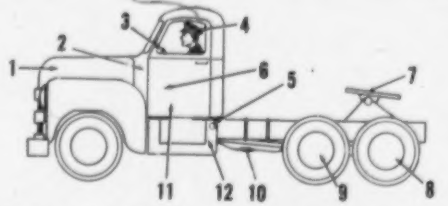
3. Two windshield wipers in good operating condition are required. Defroster must be operative when conditions require its use. (MCSR 193.78 and 193.79).

4. Clearance lamps. One at each side. MCSR 193.13.

5. Turn signals. One at each side. Vehicle must have system which will cause two front and rear signals to flash simultaneously. MCSR 193.19.

6. Horn must be operative, securely mounted, and of sufficient volume to insure that purpose for which it is intended to serve. (MCSR 193.81)

7. Fog lamps or spotlight not required. If on vehicle must be operating. (DOD)



1. Engine, body, cab, and chassis should be clean and free of excessive grease, oil, or mud. (DOD)

2. Spare fuse and bulb for each type used.

3. Steering mechanism should be in good adjustment, securely mounted and not leaking lubricant. (DOD)

4. Driver must have health certificate, operators license, copy of lease agreement on his person; he cannot smoke while driving, loading or unloading, and he must be sure he receives a copy of the firefighting instructions from the loading installation. DD Form 836 and 626.

5. Fuel tank inlet and line should be free of leaks and securely mounted. Gas cap should have a gasket and butane fuel is prohibited in an explosives area. (MCSR 193.65) (DOD)

6. Fire Extinguishers - At least one 4 lb. CO^2 type, 4 lb. dry chemical type or other types of equivalent capacity. Military require two extinguishers, but combined capacity need not exceed I.C.C. requirements for one. (MCSR 193.95(a) & DOD.) Must be securely mounted and readily accessible.

7. Fifth wheel plate and king pin must be in good operating condition. No excessive oil or grease. (MCSR 193.70)

8. Brakes must all be operative, including hand brake and air pressure warning device. (MCSR 193.40-51).

9. Wheel lugs shall be tight and none shall be missing. (MCSR 196)

10. Bare wires shall not be present in any location on either the tractor or trailer. All splices must be in good condition and properly insulated. (MCSR 193.28-32)

11. Highway warning equipment must be carried to include at least 3 clean red cloth flags (at least 12" square) with adequate standards; and 3 red electric lanterns or 3 red emergency reflectors. (MCSR 192.26 and 193.95)

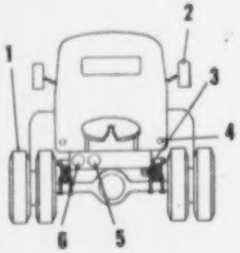
12. LPG, butane, propane fuels prohibited in explosive area.

115.415.1

Figure 17-8.—Tractor-trailer inspection chart.

FLATBED EQUIPMENT

Lighting requirements for flatbeds are same as for vans, except that all top lamps are placed at bed level. Placards must be placed on side of trailer, not attached to load.



1. Tires shall not be smooth nor have cuts or injuries extending into cord body. Tires should be properly matched.

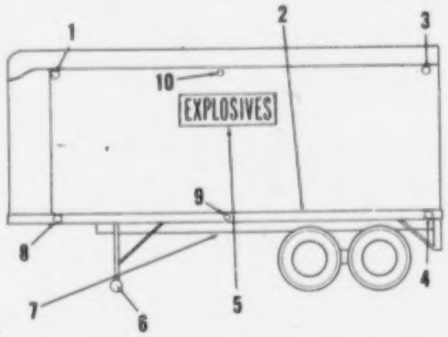
2. Two rear vision mirrors are required. They should be clean and free of all cracks.

3. Exhaust system shall be in good condition and securely mounted and shall discharge to the rear of the cab, if not vertically, beyond any saddle tanks.

4. Reflector: RED. One on each side.

5. Stop lamp: RED or AMBER or any shades between.

6. Tail lamp: RED.



1. Front side marker lamp color: AMBER. Should be operative, clean and free of all cracks.

2. Cargo space shall be clean and free of projecting objects likely to damage cargo. Floors should be tight, free of unnecessary holes, and either be of wood or be lined with nonmetallic material or nonferrous metals, unless otherwise specified by military.

3. Rear side marker lamp color: RED. Should be operative, clean and free of all cracks.

4. Rear side marker reflector color: RED. Should be clean and free of all cracks.

5. Four, 6 inch placards except "EXPLOSIVE A" and EXPLOSIVE B". They are 8 inch reflectorized placards on a contrasting background. All placards shall be displayed on front, both sides, and the rear. "EXPLOSIVES A" placards required for all Class A explosives. "EXPLOSIVES B" placards required for all class B explosives. Red reflective placards may be used on front. Placards must be furnished by carrier.

6. Landing gear assembly must be operative and must have wheels and other component parts in proper working condition.

7. Spare tire not required. If on vehicle must be in good condition.

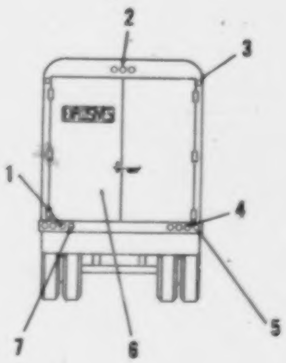
8. Front side marker reflector color: AMBER. Should be clean and free of all cracks.

9. Reflector color: AMBER.

10. Side marker lamp color: AMBER.

115.415.2

Figure 17-8. — Tractor-trailer inspection chart — continued.



1. Tail lamp color: RED. (MCSR 193.14) Should be operative, clean and free of all cracks.
2. Identification lamps. (Height optional)
3. Rear clearance lamp color: RED. (MCSR 193.14) Should be operative, clean and free of all cracks.
4. Turn signals. One at each side. MCSR 193.14.
5. Rear clearance reflector color: RED. (MCSR 193.14) Should be clean and free of all cracks one at each side.
6. Doors shall be tight and able to close securely. Hinges, latches, and safety chains should be in good condition. (MCSR 193.9(B)).
7. Stop lamp (MCSR 193.14) color: RED or AMBER. Should be operative, clean and free of all cracks.

115.415.3

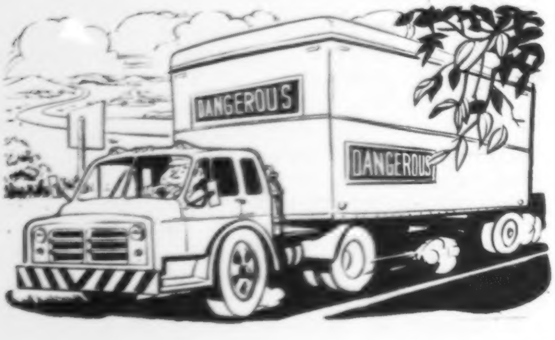
Figure 17-8. — Tractor-trailer inspection chart — continued.

No motor vehicle should be driven at a speed so slow that it may unnecessarily impede or block the normal and reasonable movement of traffic, or will violate minimum state speed requirements. If arrested, you must notify your home station and, if possible, your immediate supervisor.

DRIVING REGULATIONS

The following is quoted from the Uniform Code of Military Justice, Article III, and is applicable to military personnel: "Any person subject to this code who operates any vehicle while drunk, or in a reckless or wanton manner, shall be punished as a court-martial may direct."

Because of the intensive training and careful selection of men to be qualified as Explosives Drivers, it is assumed that all drivers transporting ammunition, explosives, or other dangerous articles are experienced, responsible, and well schooled in the hazards of their cargoes.



115.416

Figure 17-9.—DANGEROUS placards properly placed.

In spite of the capabilities of Navy drivers, however, accidents may occur.

Some of the general rules for safe driving, which are particularly applicable to the driver of a vehicle carrying dangerous cargo, are as follows:

1. Observe and obey all road signs.
2. Maintain safe clearance.
3. Exercise caution when overtaking, meeting, or being passed by other vehicles.
4. Use hand signals or directional lights when passing or turning.
5. Exercise caution when passing a stationary streetcar or bus, when local regulations permit such passing.
6. Exercise caution when approaching emergency vehicles.
7. Exercise caution when backing or maneuvering.
8. Exercise caution when stopping or parking.
9. Observe right-of-way regulations.
10. Be certain vehicle and cargo are secure.
11. Maintain a safe following distance.
12. Do not make any unscheduled, unnecessary stops. At no stop should your vehicle be left unattended.

Dangerous cargoes should not be transported during hours of darkness, except in extreme emergencies and then only with the written approval of your Commanding Officer. Except

Table 17-1.—Motor Vehicle Placards

ARTICLE	PLACARD
Explosives, Class A	EXPLOSIVES A
Explosives, Class B	EXPLOSIVES B
Flammable liquid	FLAMMABLE
Flammable solid	FLAMMABLE
Flammable compressed gas	FLAMMABLE GAS
Oxidizing material	OXIDIZERS
Corrosive liquid	CORROSIVES
Compressed gas, nonflammable	COMPRESSED GAS
Poison gas, Class A; or poison, Class B, 1000 lbs or more	POISON
Mixed ladings	DANGEROUS (plus EXPLOSIVES A when applicable)
Radioactive material	RADIOACTIVE
Explosives, Class C	None
Inert materials	None
Lading incompatible with water (used in addition to required placards)	CARGO FIRE—AVOID WATER

115.428

in extreme emergency or when no relief is available, drivers of motor vehicles will not be required to drive for periods exceeding the customary 8-hour day. A driver may be directed to travel by an activity other than his assigned activity during the 8 hours if approved by his assigned activity.

Even though you are carrying dangerous cargo, emergency type vehicles have the right of way over all other traffic, including your truck.

When traveling aboard a military reservation, be aware of military formations, whether at a halt or in motion; they have the right-of-way at all times. Be sure to exercise caution when passing or approaching such formations.

INSTRUCTIONS FOR SPECIFIC SITUATIONS

There are a number of specific situations that call for observance of certain precautions. These situations, along with applicable instructions, are indicated below.

TUNNELS. Drivers of trucks transporting ammunition, explosives, or other dangerous articles should not be routed through tunnels if such a route can be avoided. When you find it necessary to use tunnels, however, you must:

1. Contact the local police to obtain permission.
2. Request advice from the local law enforcement authorities as to existing laws.
3. Follow directions contained in your written instructions, which would include authorization to use the tunnel by your command prior to dispatching through that particular route.
4. You should try to advise the proper local authorities and your activity when you are not able to meet the scheduled time for use of the tunnel or bridge.

RAILROAD CROSSINGS. Drivers of trucks carrying dangerous cargo must exercise extreme caution when approaching railroad crossings. You must, upon approaching any railroad crossing, make a full stop not more than 50 feet from, and no closer than 15 feet to, the nearest rail of the crossing. (See fig. 17-10.) You should not proceed until you are certain that the tracks are clear. Full stops need not be made at:

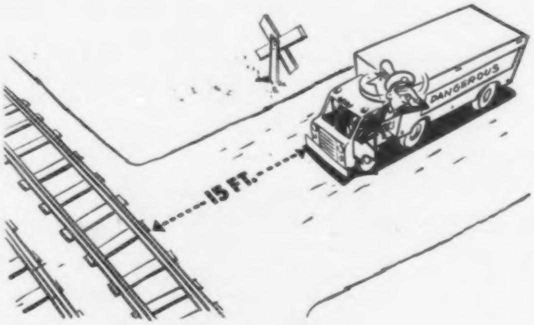
1. Streetcar crossings within the business or residential district of a town.
2. Railroad grade crossings where a police officer or a railroad crossing guard directs the traffic to proceed.
3. Abandoned or exempted grade crossings which are clearly marked as such by, or with the consent of, the proper state authority, when such marking can be read from your position in the cab of your truck.

CONVOYS AND DISTANCES. When ammunition, explosives, or other dangerous articles are being transported by motor vehicles in convoy, you should not become widely separated but must maintain a safe distance between your trucks. Generally, the safe distance is at least 300 feet; however, trucks should never be closer than 50 feet apart. The 300-foot safe following distance for vehicles carrying dangerous cargo is included on "Special Instructions for Motor Vehicle Drivers," DD Form 836 (fig. 17-5).

DRAWBRIDGES. Your motor vehicle should approach a drawbridge slowly in order that you can stop safely before reaching the lip of the draw. You should proceed only when the draw is completely closed and, if traffic signals are present, when the signal is green.

TOOL BRIDGES. When your route includes toll bridges, the transportation officer should advise you of this fact in advance of travel. You should:

1. Contact local toll bridge authorities from the origination point, or the most convenient scheduled stopping point along the route, and obtain (a) permission to use the facilities, and



115.419

Figure 17-10.—Stop at railroad crossings.

(b) information regarding their regulations concerning the transit of dangerous cargo.

2. Cooperate with local authorities by providing them with information they may require regarding your vehicle, load, and schedule, and by following their instructions concerning the movement of your vehicle over the bridge.

3. Take note of any special directions contained in your written instructions, which should include authorization to use the bridge arranged for by your activity.

SAFETY MEASURES

The danger potential of a truck loaded with ammunition, explosives, or other dangerous articles makes necessary the constant observance of safety regulations as well as their rigid enforcement. Some of the major precautions to be observed are given below.

FLAME-PRODUCING DEVICES

Explosives Drivers must not carry matches, lighters, or other fire-, flame-, or spark-producing devices in their trucks or on their person while transporting dangerous cargoes on-station or off-station.

SMOKING REGULATIONS

Smoking is prohibited within 100 feet of trucks carrying ammunition, explosives, or other dangerous articles.

WASTE MATERIAL

Extraneous waste materials must not be permitted in the cargo-carrying space with dangerous cargo.

WARNING SIGNALS

In case of accident, breakdown, or stops made for any reason on the public highways, drivers of vehicle carrying dangerous cargoes must provide suitable and adequate warning signals to approaching traffic. (See fig. 17-11.)

Daytime Warning Signals

At least three red warning flags should be carried as standard equipment on all vehicles transporting dangerous cargoes.

Red warning flags should be made of stiffened cloth material cut in squares of not less than 12 inches. Standards must be adequate to support the flags in an upright position but should not be of the "arrow" or "spike" type.

The procedures for posting and picking up red warning flags are as follows:

Ensure that all four turn flashing signals are flashing until you have placed your red flags.

One flag should be placed 100 feet in front of your truck, and one flag 100 feet in back of your truck, each in the center of the traffic lane it occupies.

If the stop is made near the crest of a hill or a curve in the road, the flag should be placed not less than 100 feet and not more than 500 feet from the vehicle in the direction of the hill or curve.

One flag should be placed on the traffic side of your vehicle, not less than 10 feet to the front or to the rear of your vehicle, as illustrated in figure 17-11.

Red flags are NOT posted within business or residential areas.

When operating on-station, all trucks carrying dangerous cargoes must display appropriate warning signals as you would for off-station shipments.

You should ensure that all four turn signals flash simultaneously while you are picking up your red flags.

Night Warning Signals

When portable lights are necessary, only those explosion-proof types approved by the National Electric Code, Class 1, Group D, should be used within a radius of 50 feet of your vehicle.

The procedure for posting and picking up night warning lights is the same as described above for posting and picking up red warning flags.

SPECIFIC REGULATIONS

When you are driving a Navy vehicle hauling dangerous cargoes, it is required that you know and practice certain established procedures under given sets of circumstances. You assume all

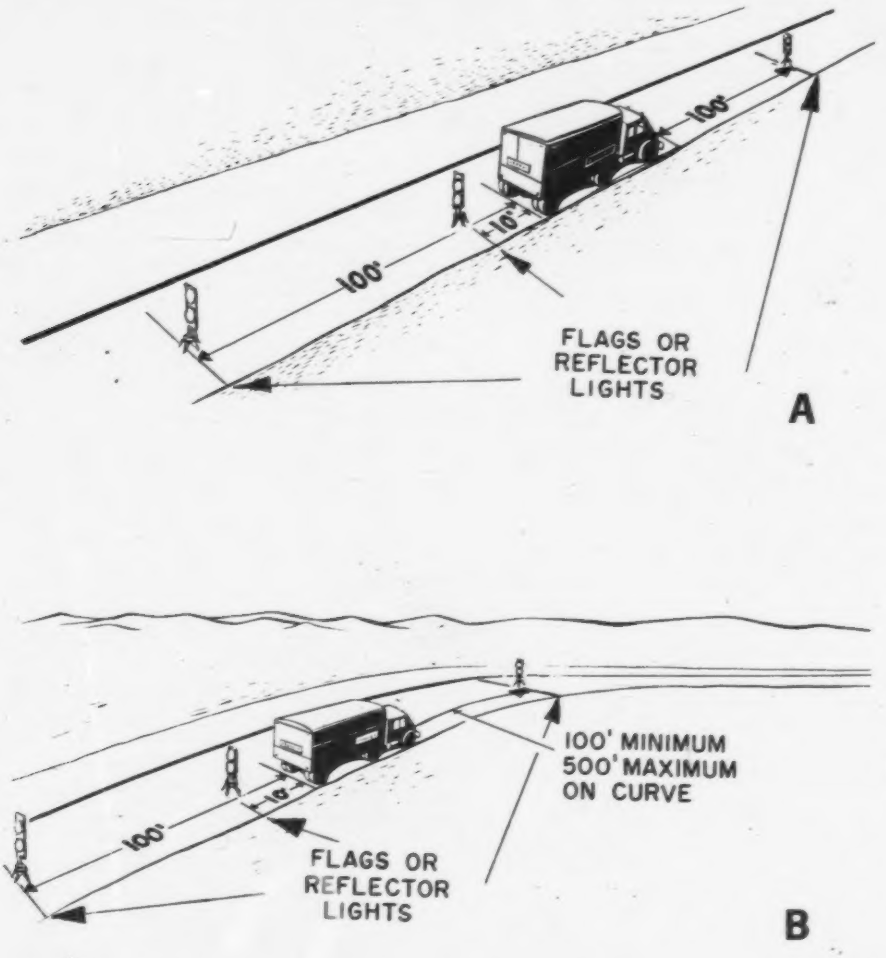

100'
10'
100'
FLAGS OR REFLECTOR LIGHTS
A
100' MINIMUM 500' MAXIMUM ON CURVE
100'
10'
FLAGS OR REFLECTOR LIGHTS
B
115.422

Figure 17-11. — Posting warning signals for highway stops.

responsibility for the safety of the public and your fellow workers. All of the regulations and required actions that will be discussed here are planned and prescribed as an aid to you, as an operator of explosives vehicles, in meeting these responsibilities quickly and adequately.

PROCEDURES FOLLOWING AN ACCIDENT

Any accident can have serious consequences, but when a truck loaded with dangerous cargo becomes involved, the disaster potential is so great that emergency safety procedures must be followed in every case. The driver of the truck has primary responsibility for taking immediate and adequate steps.

When your truck loaded with ammunition, explosives, or other dangerous articles becomes involved in an accident, you must:

1. Stop the truck immediately.
2. Turn off the ignition.
3. Set the brake and block the vehicle to prevent movement.
4. Disconnect the battery if fire is present or suspected. If fire results, you should, insofar

as possible, follow the firefighting instructions given on DD Form 836 (fig. 17-5).

5. Post warnings for other traffic.
6. Notify local law enforcement authorities.
7. Render first aid. Do not move badly injured persons unless absolutely necessary.
8. Notify supervisor.
9. Gather all broken packages and remove them to a place of safety to prevent fires or explosion.
10. Make available to law enforcement authorities and firefighting personnel information concerning the type of load and its dangerous characteristics.
11. Make available to law enforcement authorities and firefighting personnel the information given on DD Form 836. This form will provide firefighting techniques for the specific cargo, as well as safe operating distances for firemen and equipment.
12. Do not attempt to unload the disabled truck until the Safety Officer, a representative of the shipping activity, the receiving activity, or an authorized representative of another government agency has arrived on the scene.
13. Sign no insurace or release forms.
14. Express no opinions as to blame for the accident.
15. If an unattended vehicle is struck, attempt to find the owner. If this is not possible, place a copy of DD Form 518 in or on the vehicle. Notify police, and remain at the scene until police arrive or owner can be located.
16. Do not attempt to disentangle a vehicle until it is unloaded.

Every accident involving a Navy vehicle in any manner must be reported by the driver using Standard Form 91.

PROCEDURES FOLLOWING A BREAKDOWN

When a vehicle loaded with dangerous cargo is disabled because of mechanical failure or for other reasons not resulting from an accident, you are required to take certain steps to ensure the safety of the public and to protect your cargo.

In case of a breakdown, follow these instructions:

1. Pull as far off the highway as possible.
2. Do not attempt to tow the vehicle until its contents are unloaded and transferred to another vehicle.
3. Post warning signs on the highway.
4. Notify law enforcement authorities.
5. Request a police guard of two men be posted over the truck.
6. Contact your home station or destination, whichever is closer, and request another truck and trained handling personnel be dispatched at once to transfer the load and get it underway again.

A complete report must be made to the Safety Officer at your home station. The report must include all pertinent details, such as a description of the cause of the breakdown, the location, the terrain, how long the vehicle was delayed, steps taken to effect repairs, and, either a certified statement of charges if you were able to have repairs made, or a receipted bill if you paid for the repairs. The report should be turned in to your supervisor, who, in turn, should forward it to the Safety Officer.

PARKING REGULATIONS

Trucks carrying dangerous cargo must not be parked or allowed to stand, unless under direct order of local police, on any public street adjacent to, or in proximity with, bridges, tunnels, dwellings, buildings, or places where persons work, congregate, or assemble. Loaded trucks must not be parked on stations, except in locations approved and authorized by the Bureau of Naval Weapons and designated by the Commanding Officer, and then only in accordance with the following regulations:

1. Loaded trucks should not be parked overnight, except when late or weekend arrival does not permit immediate unloading. In this case, trucks loaded with ammunition, explosives, or other dangerous articles must be parked in an area sufficiently remote from station facilities to comply with quantity-distance requirements for the weight of ladings and type of explosives of all trucks parked in the area.
2. Loaded trucks must not be left in open areas between magazines unless they contain the same type of material, and their combined quantities do not exceed the explosive limits of the magazine.
3. Loaded trucks must not be left next to magazines unless the total explosive content of the truck and the magazine does not exceed the explosive limit of the magazine.
4. Loaded trucks parked in a restricted area should have the engine turned off, the brakes set, the rear wheels blocked, and the ignition key left in place.

Drivers of vehicles transporting dangerous cargo should not park near fuel pumps or in similar areas except when refueling.

Drivers of trucks carrying dangerous cargo must comply with these regulations unless ordered to do otherwise by competent authority.

PROCEDURE IN CASE OF DELAY OF MORE THAN 5 HOURS

If, for any reason, a truck carrying dangerous cargo is delayed more than 5 hours, the driver must report the delay to the Duty Officer or Transportation Officer at his home station.

PROCEDURE WHEN REFUELING A LOADED TRUCK

Ordinarily, refueling will not be necessary for a vehicle carrying dangerous cargo if your vehicle was fueled prior to loading and departure from the station. When refueling is necessary on long trips, however, you will be responsible for observing specific safety precautions. The following procedures apply during refueling operations:

1. The engine must be turned off.
2. The lights must be turned off.
3. One driver must stand by with a fire extinguisher. (See fig. 17-12.)
4. The nozzle of the fuel hose must be in continuous and firm contact with the intake pipe of the fuel tank or be otherwise grounded. (See item K of figure 17-2.)
5. Under no condition should your truck be fueled simultaneously with other vehicles.

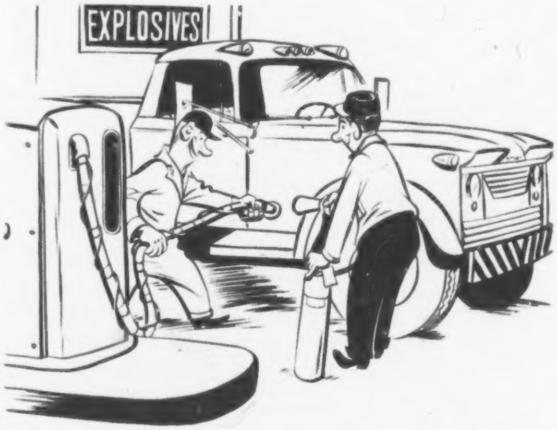
PROCEDURES ABOARD SHIPS, FERRIES, AND OTHER VESSELS

When a truck loaded with dangerous cargo must use water transportation enroute, you must necessarily share responsibility for the safety of the public and your cargo with the authorities representing the vessel you will travel on. You must observe the following procedures:

1. Deliver to the master of the ship, or to his designated representative, a letter of identification requesting transportation. The letter should be signed by the Commanding Officer of the station where the shipment was loaded. Whenever possible, such letters should be mailed prior to the trip. (You should always have a copy of the letter for presentation.)
2. Deliver to tne ship's representative the shipping document or other shipping papers containing the full description of the cargo. These papers will be returned to you.
3. Drive your truck to the location indicated by the ship's representative.
4. Shut off the engine and do not restart it until the ship is docked.
5. Turn off all truck lights and do not relight them until the ship is docked.
6. Set the brakes securely to pevent movement.
7. Remain with your truck.
8. Make no repairs or adjustments to your truck while aboard ship.
9. Do not smoke and warn others against smoking within 100 feet of your vehicle.
10. Obey all instructions given by ship personnel during the voyage and during drive-on and drive-off operations.

DRIVING IN CONGESTED AREAS

Wheneve possible, vehicles transporting dangerous cargo will not be routed through cities, areas of dense population, or areas of industrial density. Some localities forbid, through local ordinances, transporting of dangerous cargo through their municipalities. When it is possible to avoid cities, areas of dense population, or



115.424

Figure 17-12.—When refueling, ground the fuel hose and stand by with a fire extinguisher.

areas of industrial density, the proper authorities should be advised in advance of the proposed trip. The authorities will then recommend the desirable route for your truck to follow and will provide escorts if they deem it necessary. If you find that you must pass through a city having restrictive ordinances concerning trucks carrying dangerous cargo, you should call local police and request advice before approaching the outskirts of the municipality. In all cases, you will comply with local ordinance and cooperate in every way with the local police.

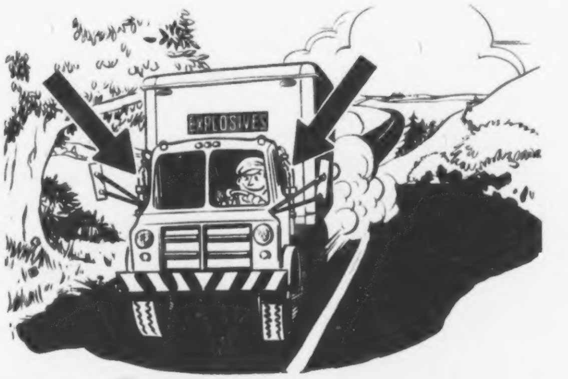
FIRE REGULATIONS

The danger of fire is inherent in every motor vehicle loaded with ammunition, explosives, or other dangerous articles. The operator of a vehicle carrying dangerous cargo must thoroughly understand the following regulations.

You must know the contents of the load and be aware of its hazards. You will be given written firefighting instructions appropriate to the specific articles you are transporting. These specific instructions will be contained in DD Form 836.

Each vehicle loaded with Class A or Class B explosives should be equipped with two portable fire extinguishers. (See fig. 17-13.) A vehicle loaded with inert or Class C explosives is required to carry one fire extinguisher. You will be instructed and drilled thoroughly in the use of fire extinguishers. Information on two types of fire extinguishers is given in figure 17-14.

Each fire extinguisher must be properly filled, securely bracket-mounted, readily accessible, and easily removable for use. Each fire extinguisher should be of a 15 pound carbon



115.426
Figure 17-13. — Fire extinguishers must be accessible.

	CARBON DIOXIDE TYPE	DRY CHEMICAL TYPE
LEARN HOW TO OPERATE ALL TYPES	15 LB SIZE	4 LB SIZE 10 LB SIZE
HOW TO USE	OPEN VALVE	TURN HANDLE WHEEL AND SQUEEZE NOZZLE VALVE
RANGE OF STREAM	6 TO 8 FEET	(10 LB SIZE) 8 TO 10 FEET
IMPORTANT	NOTE NOT PARTICULARLY EFFECTIVE IN HIGH WINDS	NOTE THIS TYPE AND THE VAPORIZING LIQUID AND CARBON DIOXIDE TYPES ARE NOT SUITABLE FOR FIRES IN METAL SUCH AS MAGNESIUM, SODIUM, OR FINE STEEL TURNINGS

3.158
Figure 17-14. — Know your fire extinguishers.

dioxide (CO_2) type, or a 4- or 10-pound dry chemical type (purple-K Powder). When all stocks of CO_2 extinguishers are exhausted, use of Purple-K Powder extinguishers is required. (Purple-K is a potassium bicarbonate powder extinguisher stocked under FSN Y4210-808-4544.)

Should a fire break out on your truck carrying dangerous cargo, you should stop the truck as far from the highway as possible. If any part of the truck except its actual contents catches fire, you should use hand extinguishers immediately in attempting to extinguish the fire. You must make every effort to prevent the fire from reaching the contents of your vehicle. You should not attempt to fight the fire unless you are reasonably certain that it is burning only on the outside of the containers and has not reached the contents. If fire does reach the contents of the containers (or if fire in any part of the vehicle cannot be controlled with the equipment at hand), you must:

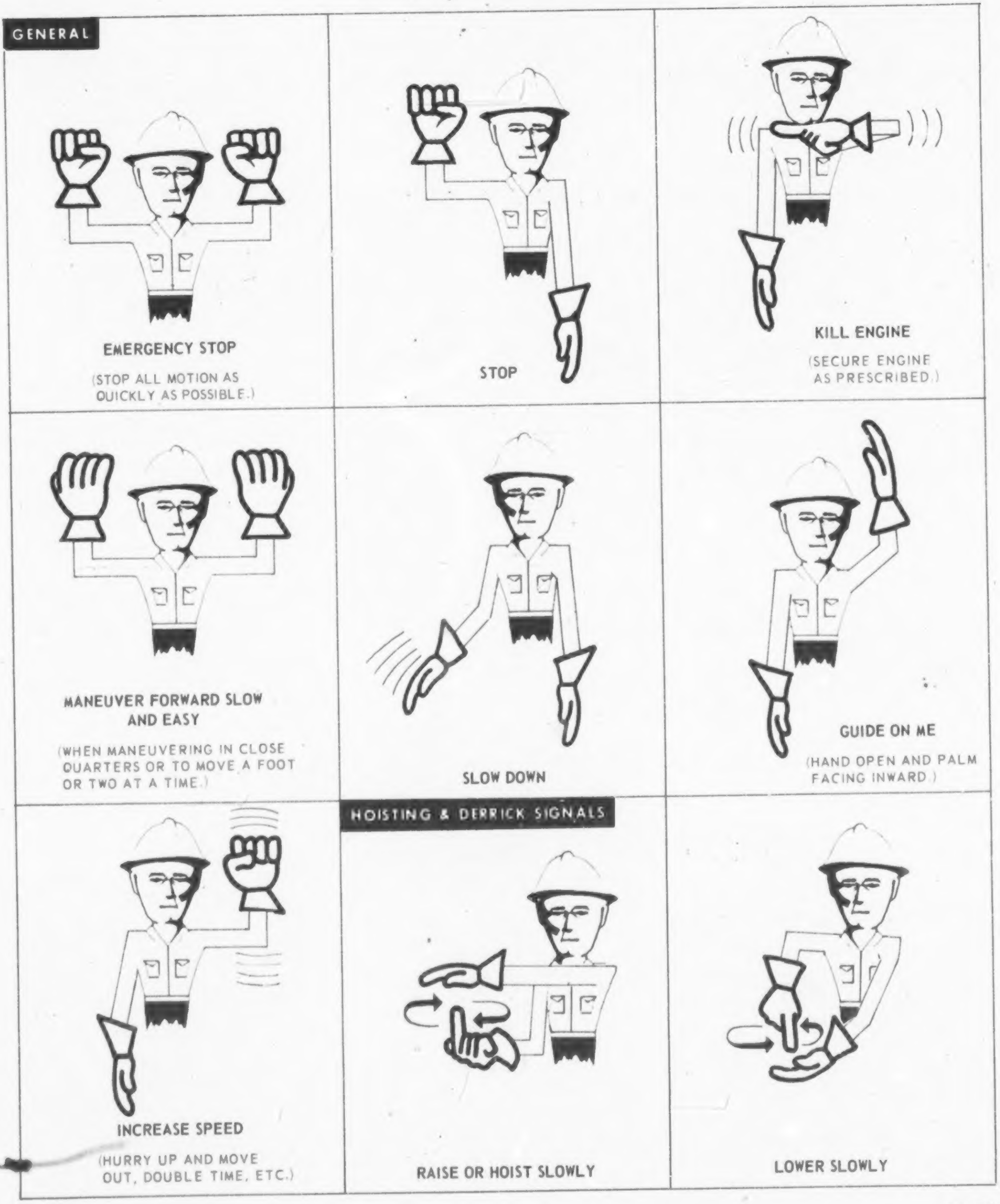
1. Notify police and fire department by the best means available, and upon their arrival, furnish the specific instructions contained in your DD Form 836.

2. Give public warnings by the best means available to keep at least a half mile from the fire in all directions.

When you are transporting ammunition, explosives, or other dangerous articles, you should not drive past fires of any kind burning on or near the highway until you can determine that such passing can be made safely and without stopping.

APPENDIX I

HAND SIGNALS



GENERAL

EMERGENCY STOP

(STOP ALL MOTION AS QUICKLY AS POSSIBLE.)

STOP

KILL ENGINE

(SECURE ENGINE AS PRESCRIBED.)

MANEUVER FORWARD SLOW AND EASY

(WHEN MANEUVERING IN CLOSE QUARTERS OR TO MOVE A FOOT OR TWO AT A TIME.)

SLOW DOWN

GUIDE ON ME

(HAND OPEN AND PALM FACING INWARD.)

INCREASE SPEED

(HURRY UP AND MOVE OUT, DOUBLE TIME, ETC.)

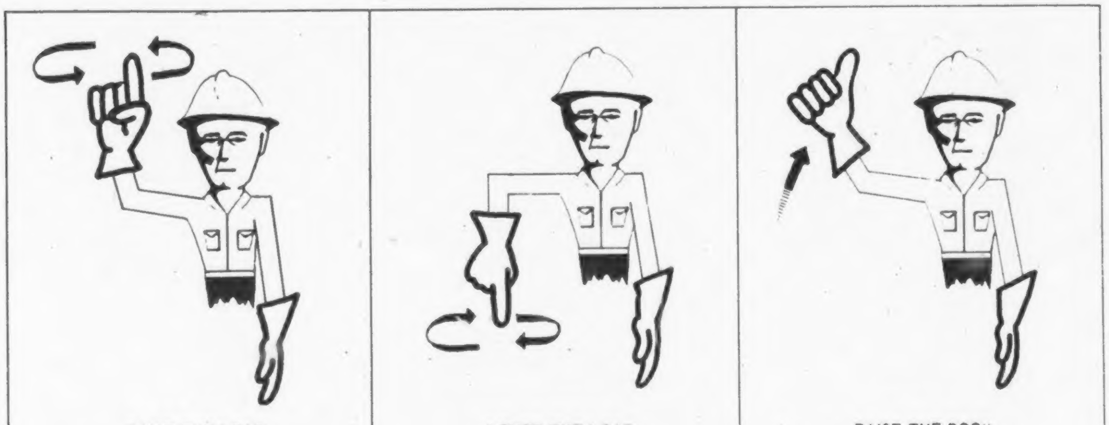
HOISTING & DERRICK SIGNALS

RAISE OR HOIST SLOWLY

LOWER SLOWLY

29.86.1

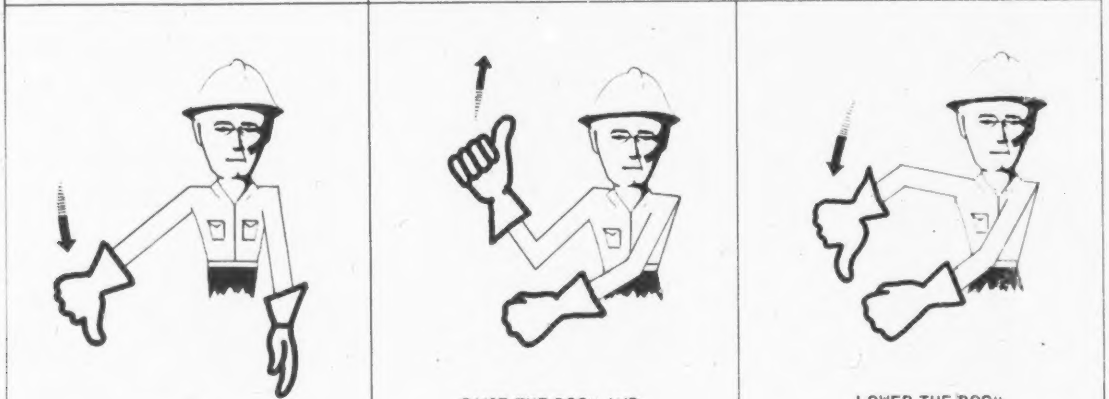
Appendix I. — Hand Signals.



RAISE THE LOAD

LOWER THE LOAD

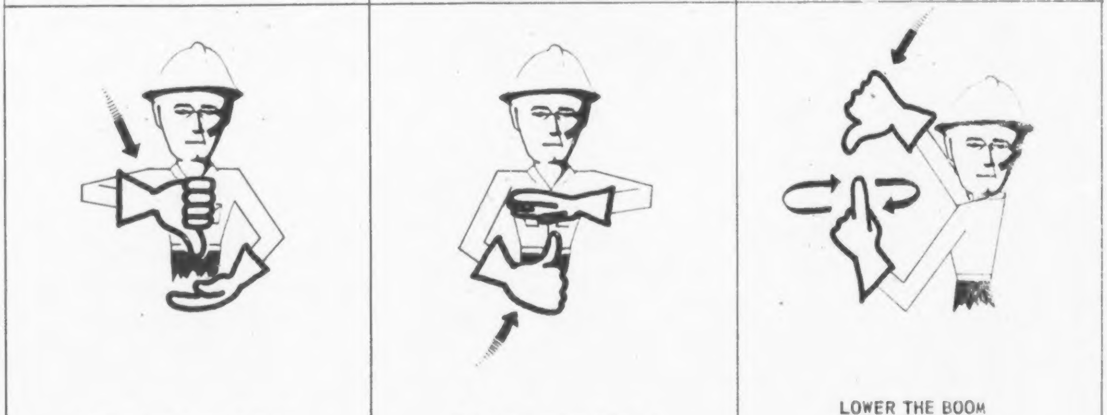
RAISE THE BOOM



LOWER THE BOOM

RAISE THE BOOM AND HOLD THE LOAD

LOWER THE BOOM AND HOLD THE LOAD



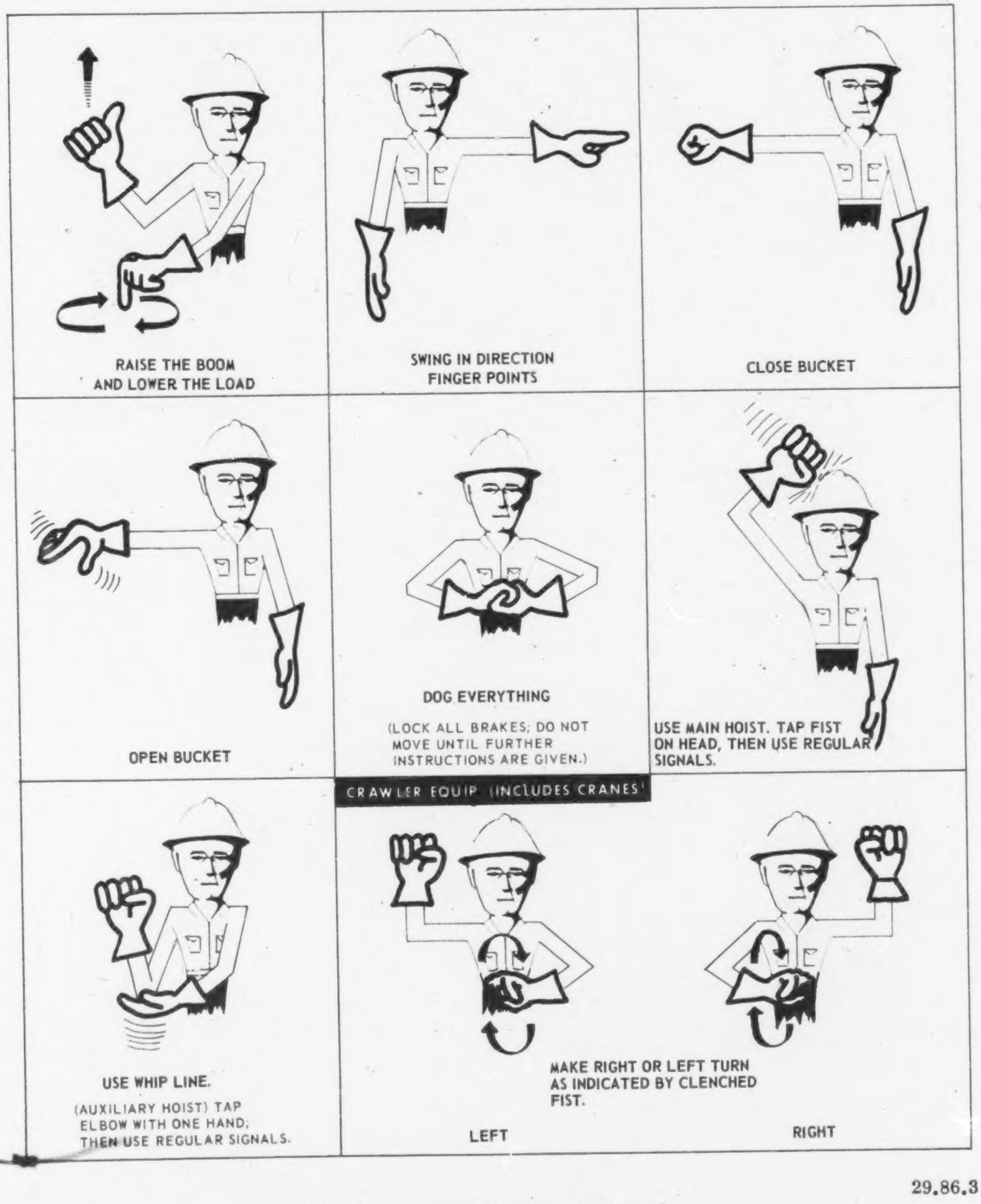
LOWER THE BOOM SLOWLY

RAISE THE BOOM SLOWLY

LOWER THE BOOM AND RAISE THE LOAD

29.86.2

Appendix I. — Hand Signals — continued.



RAISE THE BOOM AND LOWER THE LOAD

SWING IN DIRECTION FINGER POINTS

CLOSE BUCKET

OPEN BUCKET

DOG EVERYTHING

(LOCK ALL BRAKES; DO NOT MOVE UNTIL FURTHER INSTRUCTIONS ARE GIVEN.)

USE MAIN HOIST. TAP FIST ON HEAD, THEN USE REGULAR SIGNALS.

CRAWLER EQUIP. (INCLUDES CRANES)

USE WHIP LINE.

(AUXILIARY HOIST) TAP ELBOW WITH ONE HAND; THEN USE REGULAR SIGNALS.

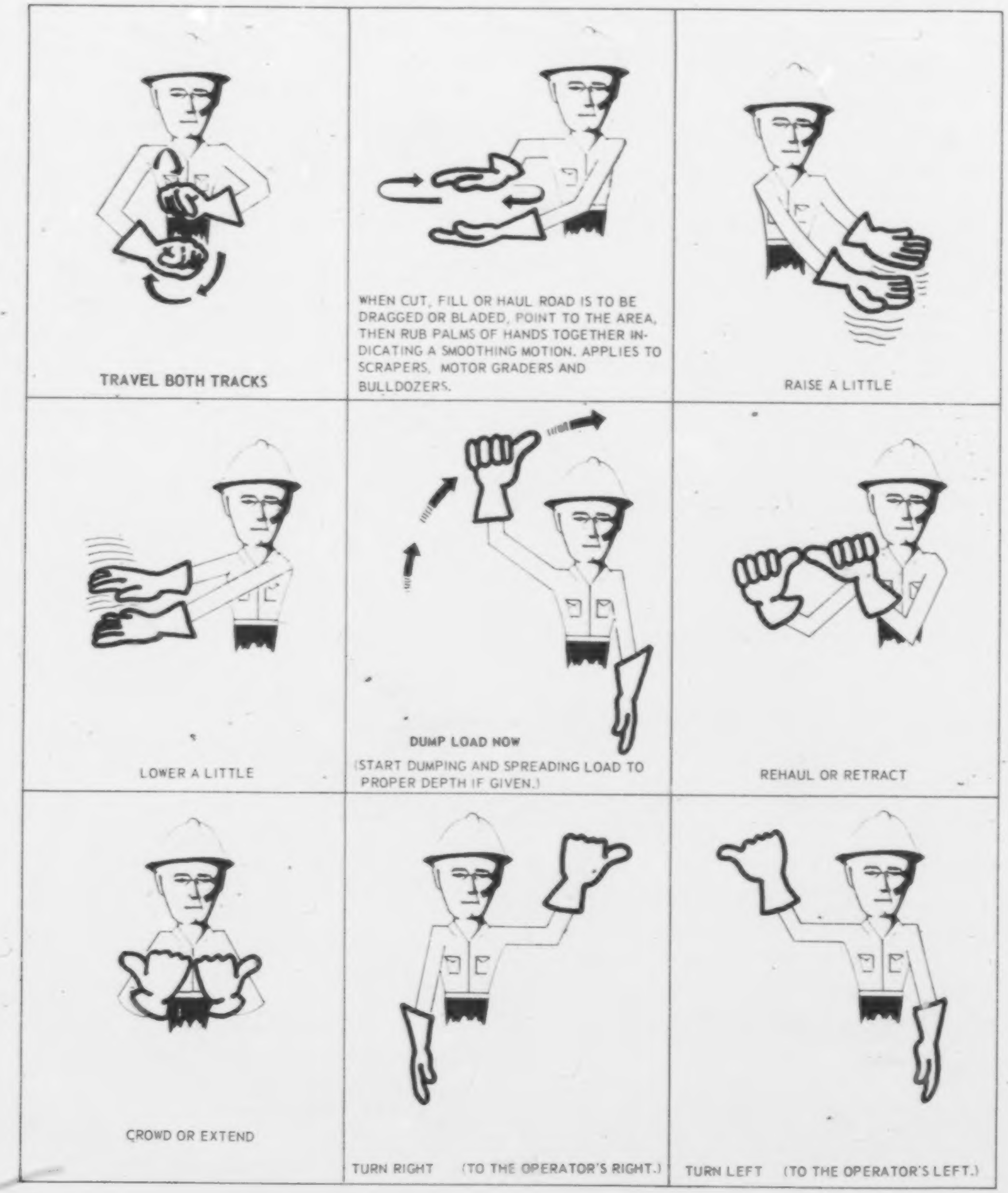
MAKE RIGHT OR LEFT TURN AS INDICATED BY CLENCHED FIST.

LEFT

RIGHT

29.86.3

Appendix I. — Hand Signals — continued.



TRAVEL BOTH TRACKS

WHEN CUT, FILL OR HAUL ROAD IS TO BE DRAGGED OR BLADED, POINT TO THE AREA, THEN RUB PALMS OF HANDS TOGETHER INDICATING A SMOOTHING MOTION. APPLIES TO SCRAPERS, MOTOR GRADERS AND BULLDOZERS.

RAISE A LITTLE

LOWER A LITTLE

DUMP LOAD NOW

(START DUMPING AND SPREADING LOAD TO PROPER DEPTH IF GIVEN.)

REHAUL OR RETRACT

CROWD OR EXTEND

TURN RIGHT (TO THE OPERATOR'S RIGHT.)

TURN LEFT (TO THE OPERATOR'S LEFT.)

29.86.4

Appendix I. — Hand Signals — continued.

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